APPENDIX F - NUTRIENT EXISTING LOAD SOURCE ASSESSMENT IN THE LOWER GALLATIN TMDL PLANNING AREA

F.1 Introduction

The appendix outlines the process by which existing nutrient loads were quantified and allocated to non-point sources in impaired stream segments at baseflow conditions. These case studies provide the methodology used for TN and TP analyses for the nutrient TMDLs developed in this Lower Gallatin TMDL document. Godfrey Creek is a catchment which drains to the Gallatin River and which is dominated by agricultural land uses. Bozeman Creek represents a mixture of different land uses including agriculture, residential and urban sources of nutrients. Figures and tables for all other streams for which nutrient TMDLs were developed are included in Appendix F and follow the 2 examples.

Existing nutrient loads were characterized by analyzing the changes in TN and TP loading between sampling points for samples collected in the same time period using a range of available spatial data. Load estimates were then checked against all data for consistency. Groundwater data from the basin, NPDES permit locations and septic density spatial data were used in combination with land use information to determine loading from different non-point sources. A nutrient source assessment completed in 2009 for all nutrient impaired streams in the Lower Gallatin TMDL project area was used extensively (**Attachment B**). The source assessment had two primary objectives: (1) to assess existing conditions with regards to land use and riparian condition, and (2) identify potential pollutant sources within the watershed and their ability to impact each stream during late-summer flow conditions. Finally, United States Department of Agriculture-National Agricultural Statistics Service (USDA-NASS) CropScape (http://nassgeodata.gmu.edu/CropScape/), was used as it proved to be the most detailed land use information available for the Lower Gallatin and was a valuable tool to identify changes in agricultural practices from pasture/rangeland to irrigated and dryland cropping. The dominant agricultural types have typical accuracies from the mid-80% to mid-90% for this data. A more coarse land use map of the Lower Gallatin project area may be found in Appendix A (Figure A-9).

Analyses of existing nutrient loading for identified TN, TP and $N0_3$+ $N0_2$ impairments in the Lower Gallatin TMDL project area heavily on water quality data collected in the nutrient impaired stream segments since 2002 with most data collected in 2008 and 2009. In addition to the 2009 Lower Gallatin TPA source assessment and CropScape application from NASS, existing water quality reports and publications were used where applicable. Interviews with irrigation ditch operators proved valuable in understanding the seasonality and volume of flow in their networks.

The Lower Gallatin TMDL project area is a complex system with numerous inter-basin water transfers via irrigation diversion and delivery. Existing source assessments used all available data to best characterize the origins of the existing nutrient loads.

F.2 Source Categories

The source area based loading assessment evaluated nutrient contributions from the following sources:

- Cropping (irrigated and dryland)
- Developed (infrastructure and residential development)

- Forest (and wetlands)
- Natural background
- Pasture/Rangeland
- Subsurface wastewater disposal and treatment (individual, community septic systems and WWTPs that discharge to groundwater)
- Urban
- Point sources

Source assessment information for natural background as well as all sources evaluated within the area based approach is described in detail within this section. Note: Although road-related sediment was incorporated into the sediment TMDLs, it is not discussed within this section because it is not a significant nutrient source; only a small fraction of phosphorus is bound to the sediment and much of this load occurs during the non-growing season.

F.2.1 Agriculture

Although the majority of cattle are typically not grazing along the valley bottoms during the growing season, there are several possible mechanisms for the transport of nutrients from agricultural land to surface water during the growing season. The potential pathways include: the effect of winter grazing on vegetative health and its ability to uptake and nutrients and minimize erosion in upland and riparian areas, breakdown of excrement and loading via surface and subsurface pathways, delivery from grazed forest and rangeland during the growing season, transport of fertilizer applied in late spring via overland flow and groundwater, and the increased mobility of phosphorus caused by irrigation-related saturation of soils in pastures (Green and Kauffman, 1989).

Pasture/Rangeland

Pasture is managed for hay production during the summer, and for grazing feed during the fall and spring. Hay pastures are fairly thickly vegetated in the summer, less so in the fall through spring. The winter grazing period is long (October – May) and through trampling and consumption reduces biomass at a time of the year when it is already low. Commercial fertilizers are used infrequently in the watershed, but cattle manure is applied naturally from October through May in larger quantities (higher cattle density) than on the range and forested areas.

Rangeland has much less biomass than other land uses, and therefore contributes fewer nutrients from biomass decay. However, grazing impacts (manure deposition) do factor in. Similar to the forest areas, rangeland is grazed during the summer months in the watershed. This grazing is handled similar to the grazing in the forest areas.

Irrigated and Dryland Cropping

Cropping practices in the Lower Gallatin TPA are dominated by irrigated and dryland production of small grains with smaller acreages of potatoes, peas and corn. This category also includes sod farms. Irrigated lands are most usually continuously cropped with annual soil disturbance and fertilizer inputs. Dryland cropping may have fallow periods of 16 to 22 months depending on site characteristics and landowner management. Nutrient pathways include overland runoff, deep percolation and shallow groundwater flow which transport nutrients off-site.

F.2.2 Developed

Developed areas contribute nutrients to the watershed by runoff from impervious surfaces, deposition by machines/automobiles, application of fertilizers, and increased irrigation on lawns. Golf courses are included in this category. Although developed areas often have the highest nutrient loading rates, in the Lower Gallatin watershed developed areas make up a small percentage of the overall area.

F.2.3 Forest

The forested areas in the Lower Gallatin watershed are heavily timbered. Additionally, coniferous forests do not lose a large percentage of their biomass each fall (as a deciduous forest does). Therefore, overall runoff values are low for forested areas due to their capacity to infiltrate, transpire, and otherwise capture rainfall. However, some of the forested areas in the Lower Gallatin watershed are grazed, and a few have a legacy of mining in the form of tailings piles and unvegetated areas near streams. Grazing had to be applied at the hydrologic response unit HRU scale and was applied on HRUs that were predominantly within grazing allotments on the Gallatin National Forest. Hydrological response units are areas within a watershed that respond hydrologically similarly to given input. It is a means to representing the spatial heterogeneity of a watershed. It was assumed that the same number of cow/calf pairs grazing in forest or rangeland over the summer was moved to pasture during the rest of the year (October – May).

There is recent data collected by MBMG above the forest boundary from streams draining the Bridger Range which documented NO2NO3 concentrations above reference concentrations for that ecoregion. As the data could not be separated from natural background with high confidence, assessment units with headwaters in the Bridger Range combined forest and natural background source allocations (Bridger Creek, Dry Creek, Reese Creek, and Smith Creek).

F.2.4 Natural Background

The natural background component of nutrient loading was evaluated where data was available and could be identified as natural. Where data was not available the median values for reference sites as compiled by MDEQ in the associated ecoregions were used to quantify the natural load in an assessment unit.

Geology

Portions of the Hyalite Creek and Bozeman Creek drainages above the forest boundary are underlain by the Phosphoria Formation (Berg et al, 1999, Berg et al, 2000, Vuke et al, 2002, Kellogg et al, 2006). This formation has the potential to cause elevated phosphorus concentrations in groundwater and surface water. Studies done by the Gallatin National Forest and Montana State University in the 1970s documented phosphorus concentrations up to 0.50 mg/L (mean 0.07 mg/L) in Bozeman Creek above the forest boundary and elevated natural background concentrations in the Hyalite Creek drainage (Schillinger and Stuart, 1978; Glasser and Jones, 1982). Phosphorus concentrations were linked more strongly to natural processes by researchers than to land uses such as grazing and logging.

Wildlife

The effect of wildlife grazing and waste on nutrient loading is considered part of the natural background load. The contribution of wildlife was not evaluated during this project and may be greater in more heavily used areas of the watershed, however, in a multi-state study with varying densities of wildlife and livestock, wildlife were estimated to contribute a minimal nutrient load relative to livestock (Moffitt, 2009).

F.2.5 Subsurface Wastewater Disposal and Treatment

Nitrogen and phosphorus discharge by septic systems that migrate to surface waters were determined using the Method for Estimating Attenuation of Nutrients from Septic Systems (MEANSS) model. MEANSS used septic location data in the Lower Gallatin TPA to calculate distance to perennial streams and calculate a load to surface water based on local soil types. The model accounted for identified septic systems (Gallatin Local Water Quality District (GLWQD), 2010; Gallatin City-County Health Department (GCCHD), 2009) and systems that have a Montana Ground Water Pollution Control System (MGWPCS) permit. For non-residential MGWPCS permitted systems where actual current wastewater flow rates are not available, design loading rates were used in the analysis. Although design rates are typically larger than average daily rates, they were used in the absence of an accurate method to estimate average rates. Due to the large amount of septic systems in the TPA, this potential error associated with these specific permitted systems should not have any significant effect on the final analysis.

The daily load from each system was based on literature values and conservative assumptions used during permitting for subdivisions in Montana (Montana Department of Environmental Quality, 2009). Because a complete system failure is typically addressed very quickly, conservative assumptions were used for the load. The model worked well in watersheds with medium to high septic density but often appeared to overestimated loads in watersheds with low septic density. Also, the model calculated annual loads whereas the TMDLs focus on summer loading (July 1 - September 30). Annual load estimates do not take into account higher uptake rates and changes in septic use during the summer period. Another assumption of the model was that perennial streams are gaining in all reaches which does not apply to many of the streams in the Lower Gallatin TPA. Model estimates for nutrient loading were compared with the area-weighted approach but were not used in place of the area-weighted analysis as MEANSS tended to overestimate summer loading rates based on the reasons outlined above.

Separate from the MEANSS model, loading estimates for Total Nitrogen and Total Phosphorus were calculated using available influent water quality data and loading rates for wastewater treatment facilities discharging to groundwater in drainages with nutrient impaired streams. These calculations were done for the Amsterdam-Churchill WWTP (MTUS00015), Belgrade WWTP (MTX000116), and the Riverside Water & Sewer District WWTP (unpermitted; private facility).

F.2.6 Urban

Urban sources include runoff from impervious surfaces, stormwater drains and illicit pipe discharges to impaired waterbodies. For the Lower Gallatin TMDL, urban sources were identified based on nutrient loading within the sewered areas of the city of Bozeman that discharge to Bozeman Creek, Bridger Creek and the East Gallatin River. For reference, the boundaries for the city of Bozeman are functionally identical to the sewered areas.

F.2.7 Point Sources

Several nutrient point sources exist in the watershed that directly contribute loading to assessment units identified as impaired for nutrients. These include the city of Bozeman Water Reclamation Facility (WRF), the City of Bozeman MS-4 stormwater system, and the USFWS Bozeman Fish Technology Center.

F.3 Godfrey Creek Existing Load Source Assessment for TN and TP

Godfrey Creek is listed as impaired for Total Nitrogen and Total Phosphorus on the 2012 303(d) list. Godfrey Creek flows 9 miles from the headwaters on the Madison Plateau (Camp Creek Hills) through the town of Churchill to the mouth where is flows into Moreland Ditch, an irrigation canal. Water quality sampling was conducted in 2008 and 2009 (**Table F-1; Figure F-1**).

Table F-1. Nutrient data used for the Godfrey Creek assessment

Data summary	Total Nitrogen	Total Phosphorus
Total samples	15	14
Tributary data	3	3
Same day samples (9/25/2009)	7	7

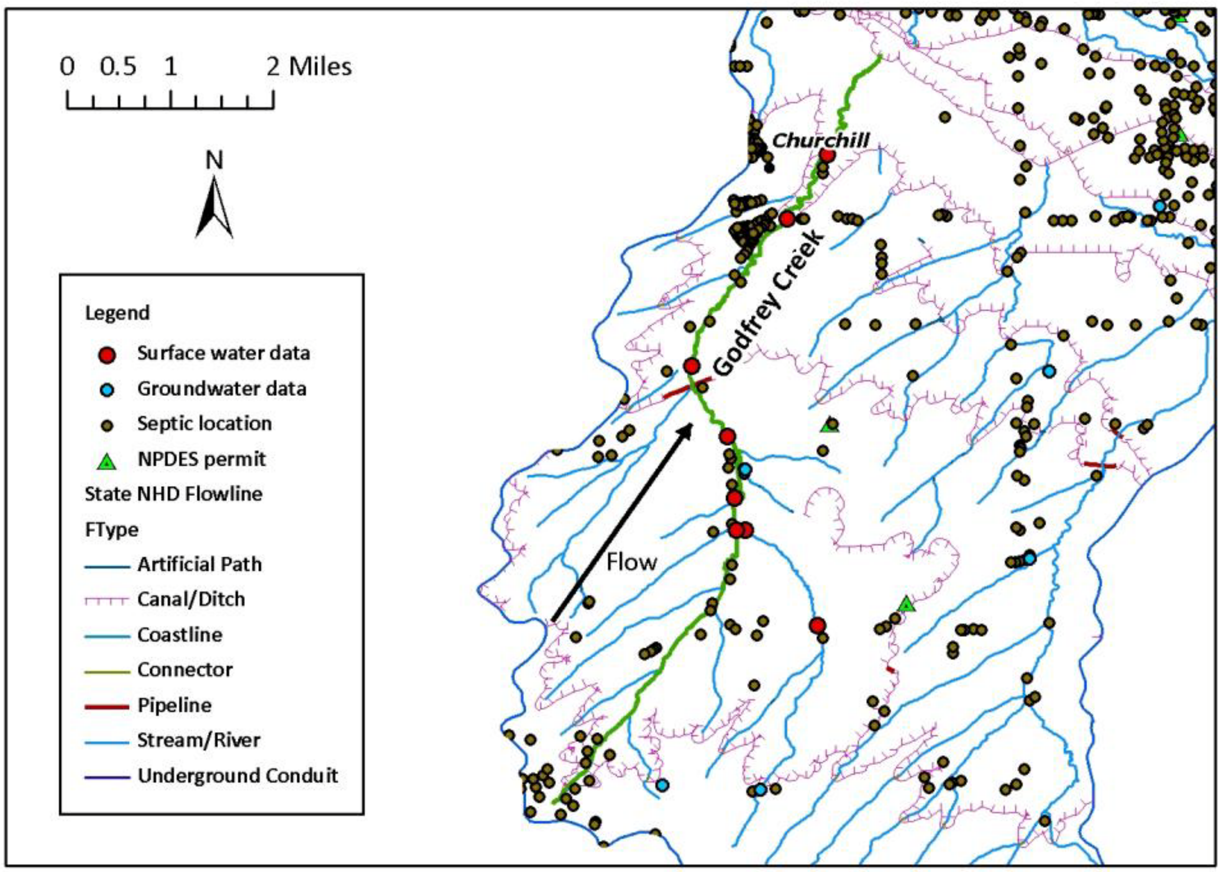

Figure F-1. Spatial data used for the Godfrey Creek existing load source assessment

For Total Nitrogen samples collected on 9/25/2009, loading from the upper reaches (GD05, GD04) comprise 87% of the peak load observed on that day (**Table F-2**). GD05 is located on the mainstem just upstream of the confluence of a tributary that enters Godfrey Creek from the east. GD04 is taken at the mouth of that tributary (**Figure E-2**). GD04A was not sampled on 9/25/2009.

Table F-2. Total Nitrogen loading on 9/25/2009 on Godfrey Creek			
Site ID	**TN load (lbs/day)**	**Change in load from upstream**	**% of peak load**
GD05	14.649	14.649	43%
GD04	14.872	14.872	44%
GD03A	32.891	3.37	10%
GD03	33.605	0.714	2%
GD02A	34.024	0.419	1%
GD02	33.891	-0.133	NA
GD01	6.978	-26.913	NA

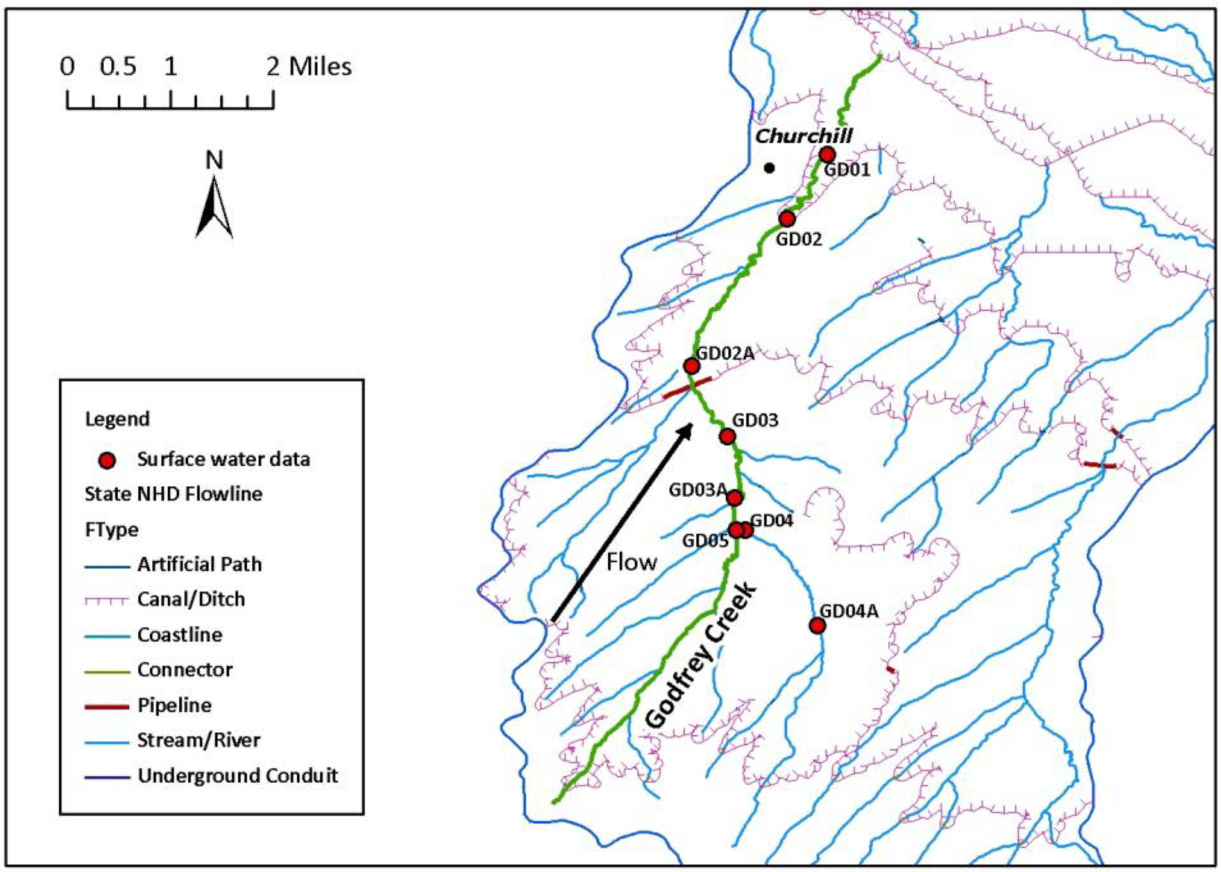

Figure F-2. Site IDs for surface water data points on Godfrey Creek

Using the available data sources including the source assessment and the CropScape application, percentages per source category were assigned for the each sample location where an increase in TN load was observed. Values were then weighted based on the % of peak load at each sample location identified in **Table F-3** and then totaled for the entire stream segment. Results were compared to other available TN data.

Table F-3. Existing load source assessment for Total Nitrogen on Godfrey Creek for 9/25/2009								
Source category	**GD05**	**GD04**	**GD03A**	**GD03**	**GD02A**	**GD02**	**GD01**	**Total**
Subsurface wastewater disposal and treatment	2.15	0.00	0.00	0.08	0.00			2.24
Forest	0.00	0.00	0.00	0.00	0.00			0.00
Developed	0.86	0.00	0.20	0.04	0.02			1.13
Pasture/Rangeland	30.14	32.78	6.44	1.32	0.80			71.48
Crops	9.90	10.93	3.27	0.65	0.41			25.16
% of peak load	43.05	43.71	9.90	2.10	1.23	0.00	0.00	

As an example, source assessment calculations for the GD05 column are shown in **Table F-4**. From **Table F-3**, the TN load at GD05 was 43.05% (=14.649/34.024) of the highest observed TN load on 9/25/2009.

Table F-4. Example calculation of area-weighted source assessment for TN at site GD05 on Godfrey Creek for 9/25/2009			
Source category	**GD05**	**GD05**	**GD05**
Subsurface wastewater disposal and treatment	5	* .4305	2.15
Forest	0	* .4305	0.00
Developed	2	* .4305	0.86
Pasture/Rangeland	70	* .4305	30.14
Crops	23	* .4305	9.90
Total	100	-	43.05

Natural background could not be determined from data collection on Godfrey Creek as the entire basin is considered to be under direct influence of anthropogenic non-point nutrient sources. Therefore, natural background was estimated based on flow statistics for 9/25/2009 sampling and the median natural background concentration for TN in the Level III Middle Rockies ecoregion as identified by MDEQ (0.110 mg/L). This method determined natural background to be 5% of the TN load in Godfrey Creek. The source categories percentages were adjusted to account for the calculated natural background TN load (**Figure F-3**).

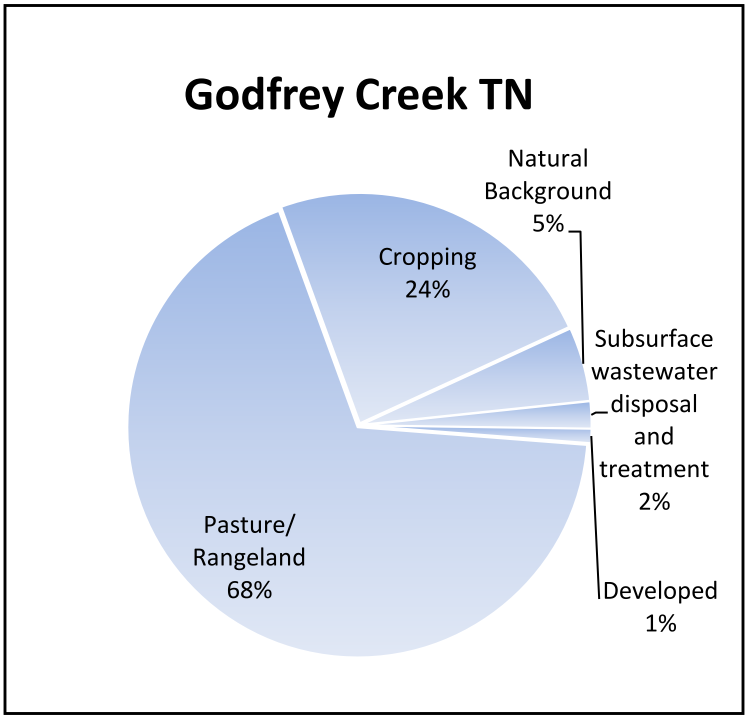

Figure F-3. Existing TN sources for Godfrey Creek

In Godfrey Creek, it was determined that Pasture/Rangeland and Cropping are the dominant sources of Total Nitrogen in the stream based on data collection efforts in 2008 and 2009, the nutrient source assessment and NASS CropScape.

For TP on Godfrey Creek, the same methodology was used (**Table E-5; Table E-6**).

Table F-5. Total Phosphorus loading on 9/25/2009 on Godfrey Creek

Site ID	TN load (lbs/day)	Change in load from upstream	% of peak load
GD05	0.43	0.43	40%
GD04	0.46	0.46	43%
GD03A	0.79	-0.10	NA
GD03	0.66	-0.13	NA
GD02A	0.84	0.18	17%
GD02	0.36	-0.47	NA
GD01	0.35	-0.01	NA

Table F-6. Existing load source assessment for Total Phosphorus on Godfrey Creek for 9/25/2009								
Source category	GD05	GD04	GD03A	GD03	GD02A	GD02	GD01	Total
Subsurface wastewater disposal and treatment	0.80	0.00			0.00			0.80
Forest	0.00	0.00			0.00			0.00
Developed	2.00	0.87			0.83			3.69
Pasture/Rangeland	32.00	36.81			12.57			81.38
Crops	5.20	5.63			3.14			13.97
% of peak load	40.00	43.31			16.54			

Natural background was estimated based on flow statistics for 9/25/2009 sampling and the median natural background concentration for TN in the Level III Middle Rockies ecoregion as identified by MDEQ (0.010 mg/L). This method determined natural background to be 20% of the TP load in Godfrey Creek. The source categories percentages were adjusted to account for the calculated natural background TN load (**Figure F-4**).

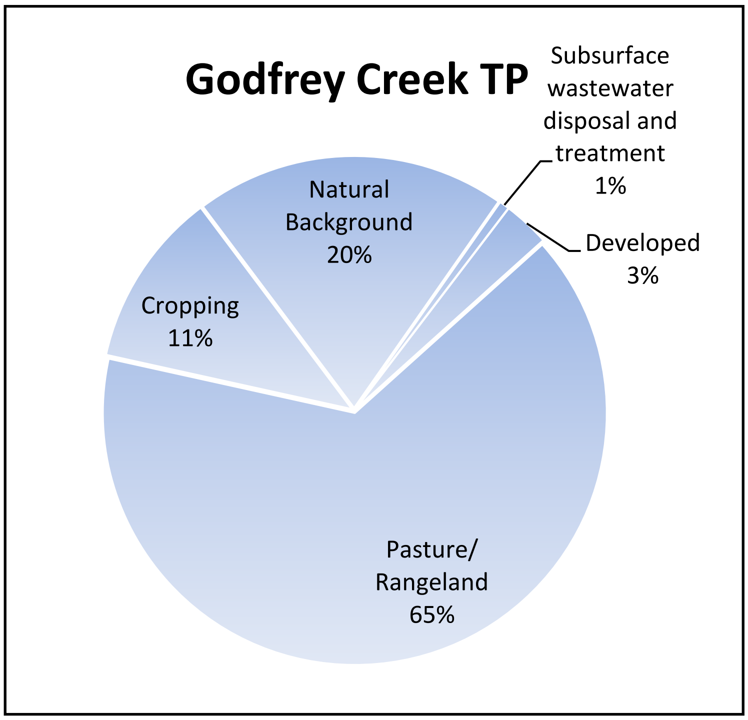

Figure F-4. Existing TP sources for Godfrey Creek

F.4 Bozeman Creek Existing Load Source Assessment for TN and TP

Lower Bozeman Creek is listed on the 2012 303(d) List for Total Nitrogen (TN) and Total Phosphorous (TP) nutrient impairment. The lower segment of Bozeman Creek flows 4.9 miles from the confluence with Limestone Creek to the mouth (East Gallatin River). Bozeman Creek originates in the Gallatin Range and flows out of Sourdough Canyon. The total length of the stream is 14 miles from the confluence of North Fork and South Fork to the mouth (East Gallatin River). Extensive water quality data is available for Bozeman Creek with the primary collection efforts occurring in 2008 and 2009. Bozeman Creek is the most well sampled waterbody in the project area and the analysis included data collected upstream of the assessment unit and from several tributaries to Bozeman Creek (**Table F-7; Figure F-5**).

Table F-7. Nutrient data used for the Bozeman Creek assessment		
Data summary	**Total Nitrogen**	**Total Phosphorus**
Total samples	44	46
Tributary data	5	5
Same day samples (9/2/2008)	5	5
Same day samples (9/15/2009)	8	8

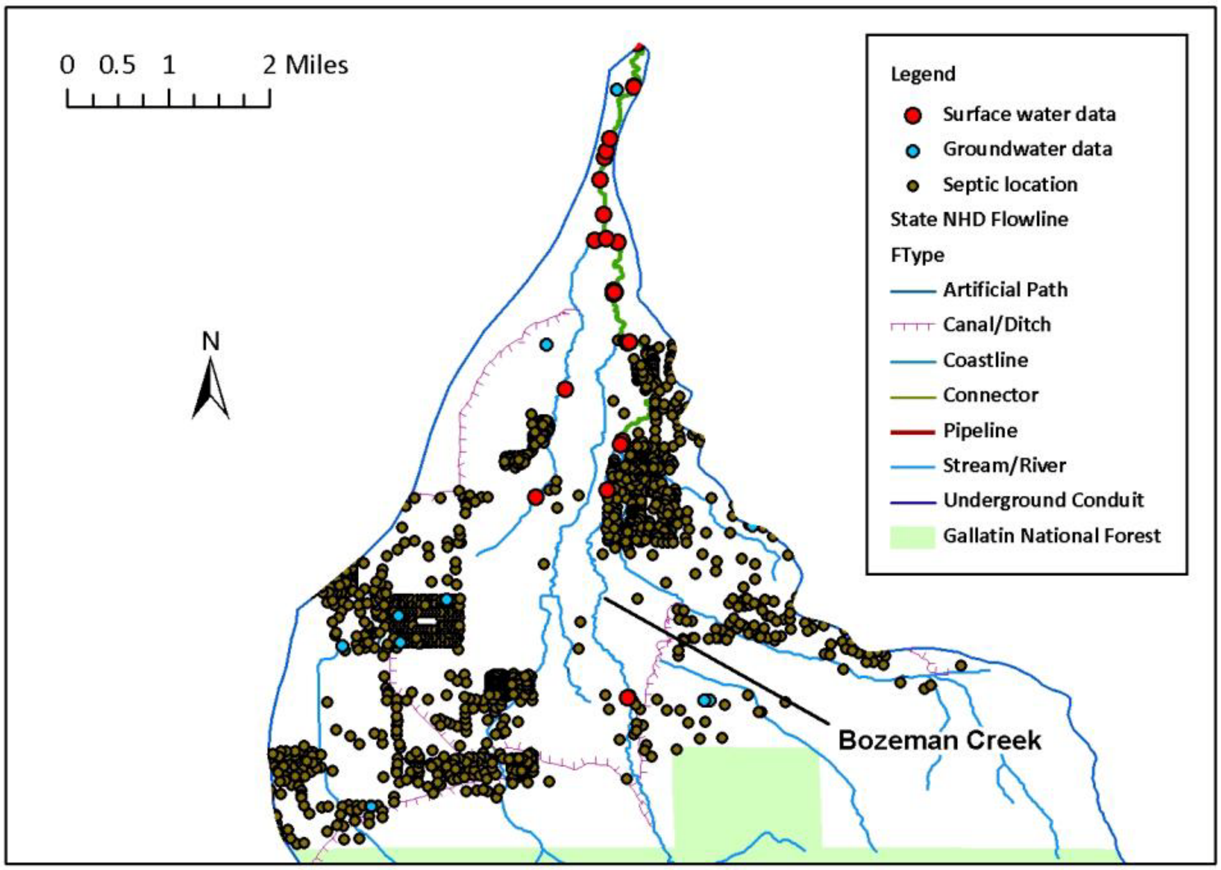

Figure F-5. Spatial data used for the lower Bozeman Creek existing load source assessment

For Bozeman Creek, there were 2 available sampling dates when water quality samples were collected at numerous points along the stream on a single day (**Figure F-6**). Therefore, loading was analyzed for both dates in addition to tributary water quality data to determine the existing sources of the TN in Bozeman Creek.

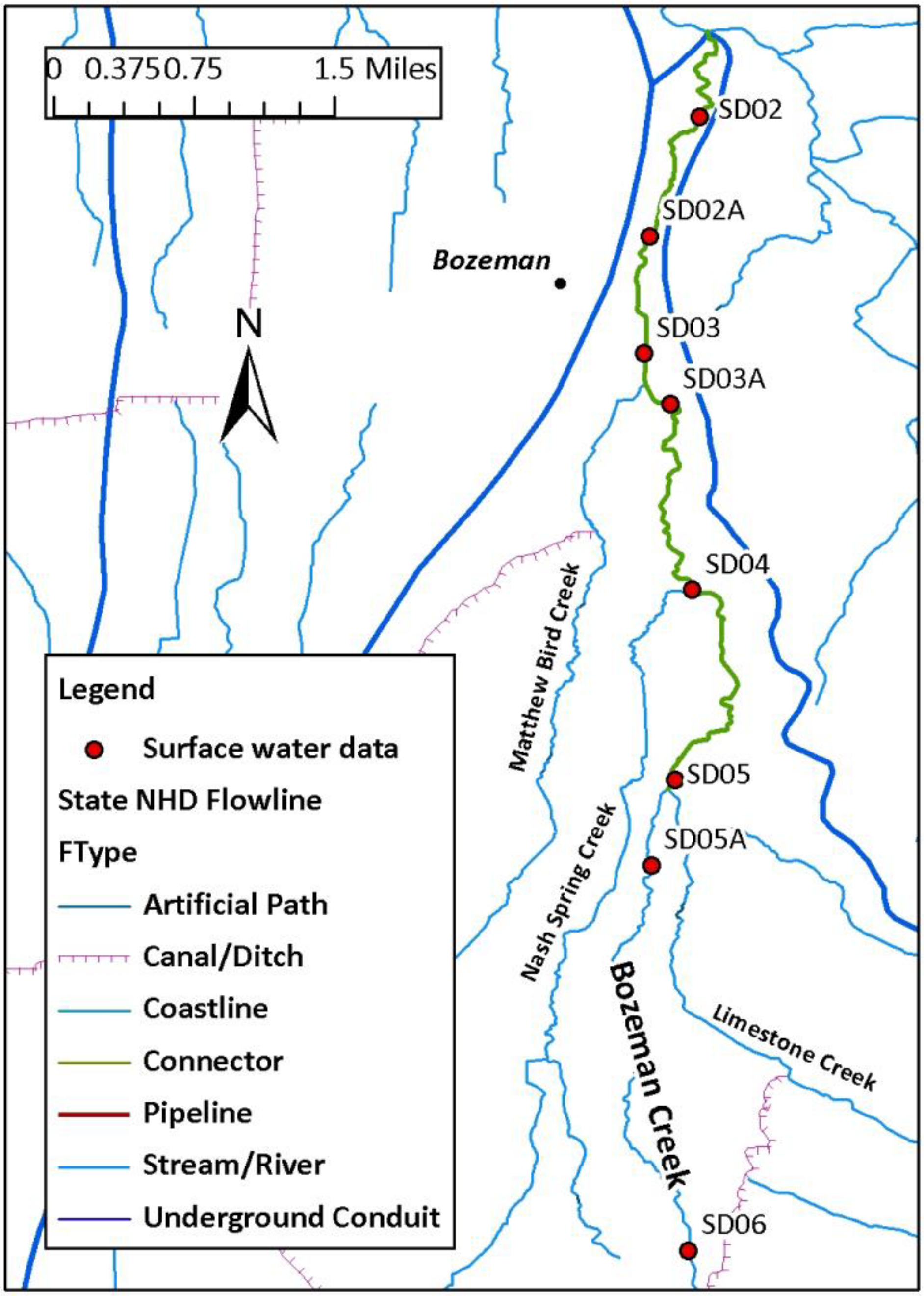

Figure F-6. Site IDs for surface water data points on Bozeman Creek

Using the available data sources including the source assessment and the CropScape application, percentages per source category were assigned for the each sample location where an increase in TN load was observed. Values were then weighted based on the % of peak load at each sample location and then totaled for the entire stream segment. Results were compared to other available TN data.

Table F-8 and **F-9** are the results of the TN load analysis for samples collected on 9/2/2008.

Table F-8. Total Nitrogen loading on 9/2/2008 on Bozeman Creek			
Site ID	**TN load (lbs/day)**	**Change in load from upstream**	**% of peak load**
SD06	2.63	2.63	2%
SD05A	*Not sampled*		
SD05	13.90	11.27	9%
SD04	30.64	30.64	14%
SD03A	*Not sampled*		
SD03	106.27	75.63	62%
SD02A	*Not sampled*		
SD02	121.97	15.70	13%

Table F-9. Existing load source assessment for Total Nitrogen on Bozeman Creek for 9/2/2008									
Source category	**SD06**	**SD05A**	**SD05**	**SD04**	**SD03A**	**SD03**	**SD02A**	**SD02**	**Total**
Subsurface wastewater disposal and treatment	0.00		3.69	5.49		6.2		0.00	15.39
Forest	2.16		0.46	0.00		0.00		0.00	2.62
Developed	0.00		5.08	5.49		21.7		0.00	32.27
Pasture/Rangeland	0.00		0.00	0.69		11.2		0.00	11.85
Crops	0.00		0.00	2.06		19.8		0.00	21.90
Urban	0.00		0.00	0.00		3.1		12.87	15.97
% of peak load	2.16		9.23	13.73		62.00		12.87	

Table F-10 and **F-11** are the results of the TN load analysis for samples collected on 9/15/2009. Nash Spring Creek enters Bozeman Creek upstream of SD04 and Matthew Bird Creek joins Bozeman Creek between SD03 and SD03A. Data collected from these tributaries on 9/15/2009 was used in the analysis for the mainstem.

Table F-10. Total Nitrogen loading on 9/15/2009 on Bozeman Creek			
Site ID	**TN load (lbs/day)**	**Change in load from upstream**	**% of peak load**
SD06	0.98	0.98	1%
SD05A	13.35	12.38	18%
SD05	14.76	1.41	2%
SD04	53.61	38.85	56%
SD03A	57.46	3.86	6%
SD03	69.23	11.77	17%
SD02A	68.96	-0.28	NA
SD02	68.88	-0.08	NA

Table F-11. Existing load source assessment for Total Nitrogen on Bozeman Creek for 9/15/2009									
Source category	**SD06**	**SD05A**	**SD05**	**SD04**	**SD03A**	**SD03**	**SD02A**	**SD02**	**Total**
Subsurface wastewater disposal and treatment	0.00	4.47	0.81	22.4	0.45	1.7			29.87
Forest	1.41	0.00	0.10	0.00	0.39	0.00			1.90
Developed	0.00	6.79	1.12	25.2	1.67	5.95			40.78
Pasture/Rangeland	0.00	4.47	0.00	2.81	3.06	3.06			13.40
Crops	0.00	2.15	0.00	5.61	0.00	5.44			13.20
Urban	0.00	0.00	0.00	0.00	0.00	0.85			0.85
% of peak load	1.41	17.88	2.03	56.02	5.57	17.0			

Mean percentages from the 2 sampling date analyses were calculated for the Bozeman Creek existing load assessment which did not include natural background. Natural background could not be determined from data collection on Bozeman Creek as loads entering the reach at the forest boundary were too small to accurately determine the natural background load separate from the forest load. Therefore, natural background for TN was estimated based on flow statistics for the 9/2/2008 and 9/15/2009 sampling events and the median natural background concentration for TN in the ecoregions which comprise the Bozeman Creek basin. This method determined natural background to be 11% of the TN load in Bozeman Creek. Source categories were adjusted to account for this percentage (**Figure F-7**).

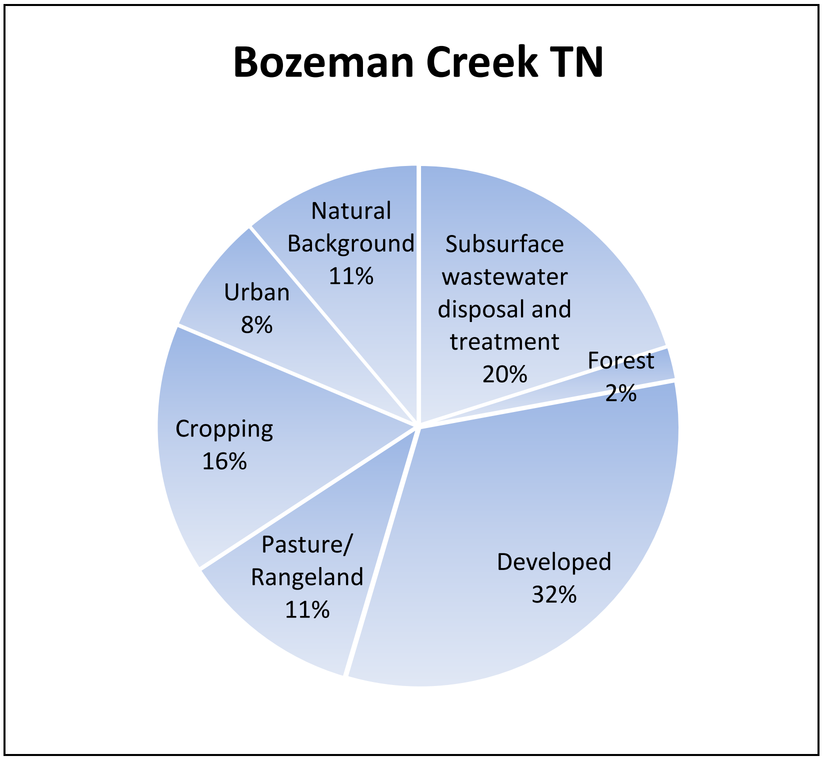

Figure F-7. Existing TN sources for Bozeman Creek

Matthew Bird Creek and Nash Spring Creek contribute large TN loads to Bozeman Creek. The existing load assessment used data collected on those tributaries to determine % loads to Bozeman Creek. In addition, the Mill-Willow irrigation canal diverts flow from Bozeman Creek and actually reduces TN loads immediately downstream of the Matthew Bird Creek and Bozeman Creek confluence. This was also accounted for in the analysis. Finally, the 9/2/2008 and 9/15/2009 data analyses had good agreement with the load increases observed in the 2008-2011 Greater Gallatin Watershed Council data collected on Bozeman Creek. In Bozeman Creek, TN sources include both agriculture and urban/residential non-point sources.

The following example was done for Bozeman Creek as an explanation as a TP TMDL was not developed for Bozeman Creek as it was determined that Bozeman Creek is not impaired for TP. **Table F-12** and **F-13** are the results of the TP load analysis for samples collected on 9/2/2008.

Table F-12. Total Phosphorus loading on 9/2/2008 on Bozeman Creek			
Site ID	**TP load (lbs/day)**	**Change in load from upstream**	**% of peak load**
SD06	5.16	5.16	60%
SD05A	*Not sampled*		
SD05	2.78	-2.38	NA
SD04	3.47	0.69	8%
SD03A	*Not sampled*		
SD03	4.97	1.50	17%
SD02A	*Not sampled*		
SD02	6.24	1.27	15%

Table F-13. Existing load source assessment for Total Phosphorus on Bozeman Creek for 9/2/2008									
Source category	**SD06**	**SD05A**	**SD05**	**SD04**	**SD03A**	**SD03**	**SD02A**	**SD02**	**Total**
Subsurface wastewater disposal and treatment	0.00			0.96		0.87		0.00	1.83
Forest	0.00			0.16		0.69		0.00	0.85
Developed	0.00			3.61		6.94		0.00	10.56
Pasture/Rangeland	0.00			1.61		2.6		0.00	4.21
Crops	0.00			0.48		1.91		0.00	2.39
Urban	0.00			0.00		1.74		14.72	16.46
Natural Background	59.90			1.2		2.6		0.00	63.71
% of peak load	59.90			8.03		17.4		14.72	

Table F-14 and **F-15** are the results of the TP load analysis for samples collected on 9/15/2009. Nash Spring Creek enters Bozeman Creek upstream of SD04 and Matthew Bird Creek joins Bozeman Creek between SD03 and SD03A. Data collected from these tributaries on 9/15/2009 was used in the analysis for the mainstem.

Table F-14. Total Phosphorus loading on 9/15/2009 on Bozeman Creek			
Site ID	TP load (lbs/day)	Change in load from upstream	% of peak load
SD06	1.33	1.33	28%
SD05A	1.78	0.45	9%
SD05	1.91	0.13	3%
SD04	2.14	0.23	4%
SD03A	2.56	0.42	9%
SD03	3.88	1.32	27%
SD02A	4.80	0.92	19%
SD02	4.34	-0.46	NA

Table F-15. Existing load source assessment for Total Phosphorus on Bozeman Creek for 9/15/2009									
Source category	SD06	SD05A	SD05	SD04	SD03A	SD03	SD02A	SD02	Total
Subsurface wastewater disposal and treatment	0.00	0.47	0.70	0.58	0.17	1.37	0.00		3.29
Forest	0.00	0.00	0.14	0.10	0.52	1.10	0.00		1.86
Developed	0.00	1.98	0.56	2.17	2.01	10.97	0.00		17.68
Pasture/Rangeland	0.00	5.20	1.11	0.96	4.97	4.11	0.00		16.35
Crops	0.00	1.79	0.28	0.29	1.05	3.02	19.18		25.61
Urban	0.00	0.00	0.00	0.00	0.00	2.74	0.00		2.74
Natural background	27.67	0.00	0.00	0.72	0.00	4.11	0.00		32.51
% of peak load	27.67	9.45	2.78	4.82	8.72	27.41	19.18		

Mean percentages from the 2 sampling date analyses were calculated for the Bozeman Creek existing load assessment which did not include natural background. Natural background was determined from the sample data as the TP load observed at the forest boundary (SD06) differentiated between forest and natural background loads based on MDEQ reference datasets. In reaches where tributaries entered the mainstem, this calculation was repeated. This method determined natural background to be 48% of the TP load in Bozeman Creek. Source categories were adjusted to account for this percentage (**Figure F-8**).

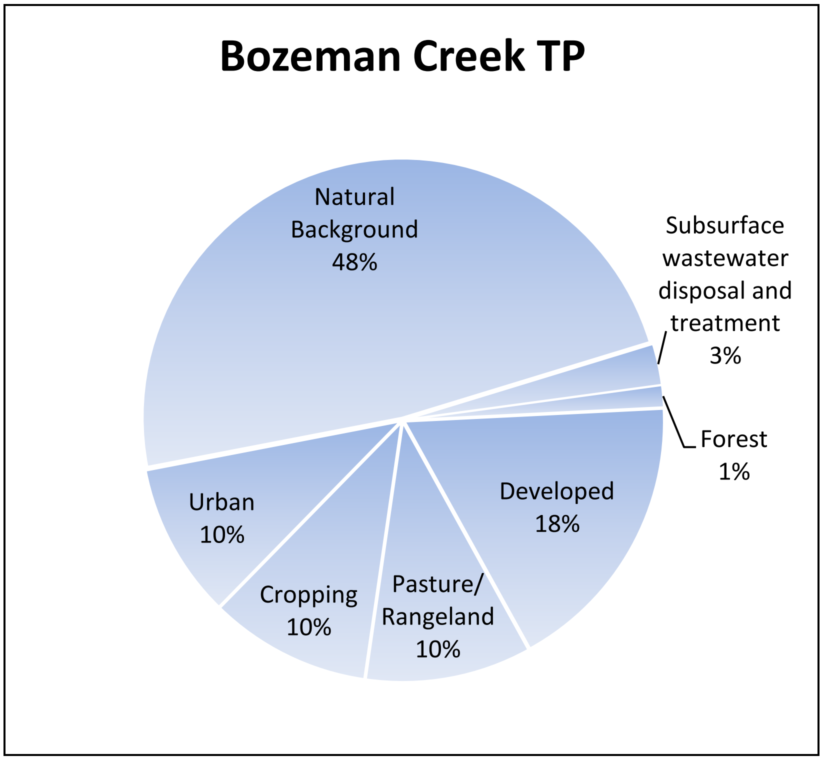

Figure F-8. Existing TP sources for Bozeman Creek

F.4 Existing Load Source Assessments for TN and TP for remaining TMDL streams

Figures displaying spatial data used in the source assessments per waterbody identify all surface water data locations but labels are only provided for those points sampled in the synoptic events used for the source assessment.

F.4.1 Bear Creek

Bear Creek is listed as impaired for total phosphorus on the 2012 303(d) list. Figures and analysis for TP source allocation are provided in this section.

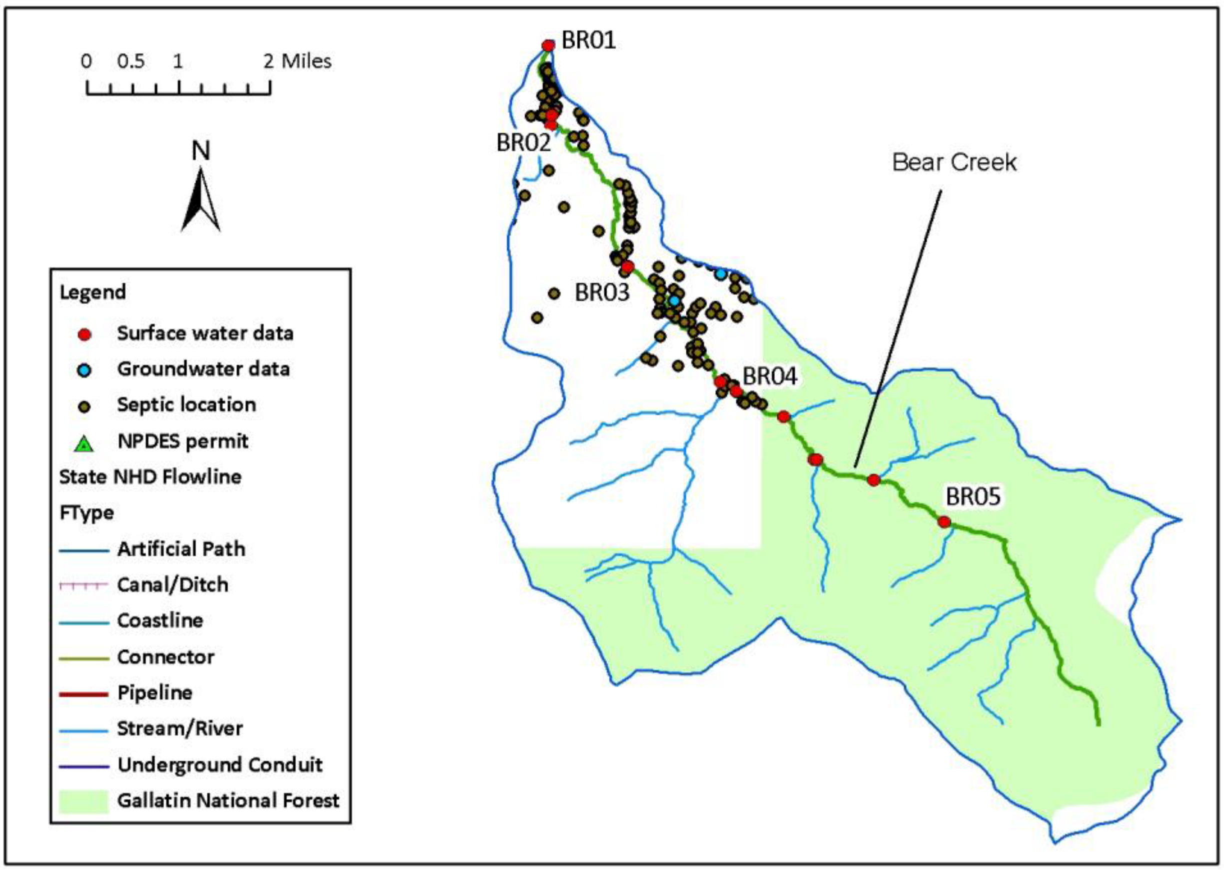

Figure F-9. Spatial data used for the Bear Creek existing load source assessment

Two synoptic sampling dates were available for Bear Creek.

Table F-16. Total Phosphorus loading on 8/26/2008 on Bear Creek			
Site ID	**TP load (lbs/day)**	**Change in load from upstream**	**% of peak load**
BRO5	5.16	0.474	65%
BRO4	2.78	0.251	34%
BRO3	3.47	0.003	0.4%
BRO2	4.97	-0.265	NA
BR01	6.24	-0.096	NA

Table F-17. Existing load source assessment for Total Phosphorus on Bear Creek for 8/26/2008						
Source category	**BRO5**	**BRO4**	**BRO3**	**BRO2**	**BRO1**	**Total**
Subsurface wastewater disposal and treatment	0.00	2.59	0.06			2.65
Forest	55.34	27.75	0.25			83.35
Developed	0.00	0.00	0.04			0.04
Pasture/Rangeland	9.77	4.14	0.06			13.97
Crops	0.00	0.00	0.00			0.00
Urban	0.00	0.00	0.00			0.00
% of peak load	65.11	34.48	0.41			

Table F-18. Total Phosphorus loading on 9/18/2009 on Bear Creek			
Site ID	**TP load (lbs/day)**	**Change in load from upstream**	**% of peak load**
BRO5	*Not sampled*		
BRO4	0.32	0.32	93%
BRO3	0.35	0.02	7%
BRO2	0.21	-0.14	NA
BR01	0.18	-0.02	NA

Table F-19. Existing load source assessment for Total Phosphorus on Bozeman Creek for 9/15/2009						
Source category	**BRO5**	**BRO4**	**BRO3**	**BRO2**	**BRO1**	**Total**
Subsurface wastewater disposal and treatment		7.00	1.00			8.00
Forest		75.13	4.00			79.13
Developed			0.67			0.67
Pasture/Rangeland		11.20	1.00			12.20
Crops						0.00
Urban						0.00
% of peak load		93.33	6.67			

Mean percentages from the 2 sampling date analyses were calculated for the Bear Creek existing load assessment which did not include natural background. Natural background was estimated based on flow statistics for the 8/26/2008 and 9/12/2009 sampling events and the median natural background concentration for TP in the ecoregions which comprise the Bear Creek basin. This method determined natural background to be 32% of the TP load in Bear Creek. Source categories were adjusted to account for this percentage (**Figure F-10**).

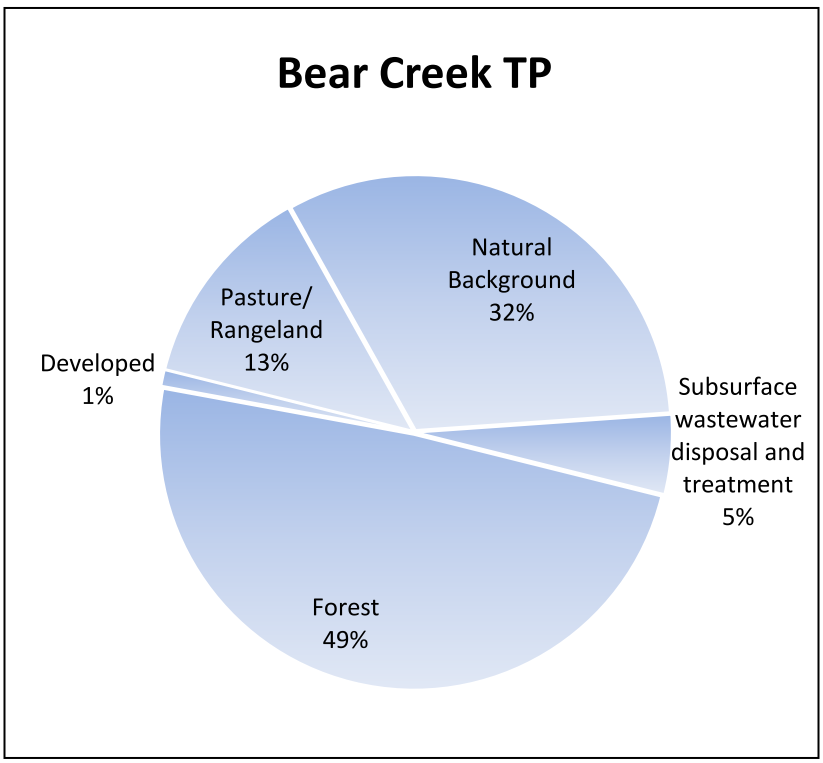

Figure F-10. Existing TP sources for Bear Creek

F.4.2 Bridger Creek

Bridger Creek is listed as impaired for nitrite + nitrate (NO_3+ NO_2) on the 2012 303(d) list. Figures and analysis for NO_3+ NO_2 source allocation are provided in this section.

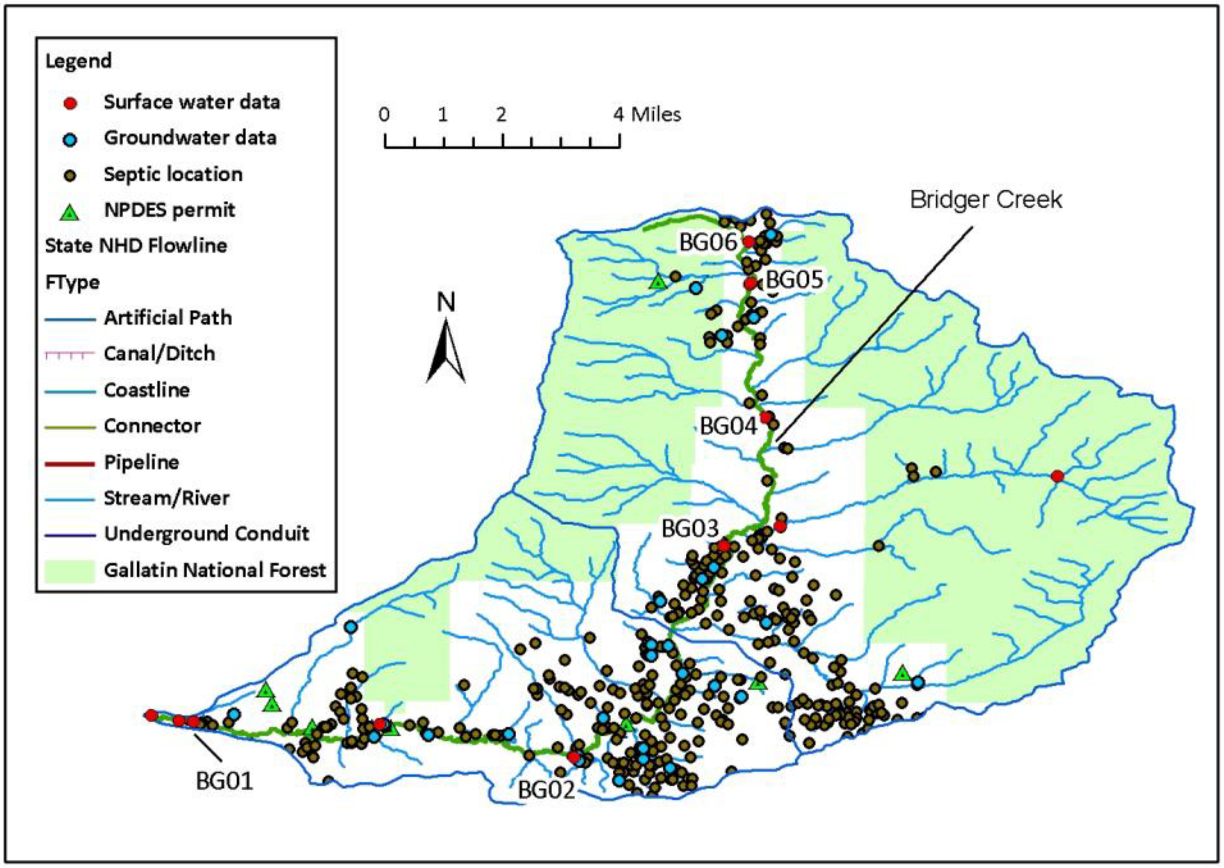

Figure F-11. Spatial data used for the Bridger Creek existing load source assessment

Table F-20. N03+ N02 loading on 8/27/2008 on Bridger Creek			
Site ID	**TP load (lbs/day)**	**Change in load from upstream**	**% of peak load**
BG06	0.04	0.04	0.0%
BG05	0.71	0.67	6%
BG04	0.88	0.17	1%
BG03	1.99	1.11	9%
BG02	6.25	4.26	35%
BG01	12.10	5.85	48%

Table F-21. Existing load source assessment for N03+ N02 on 8/27/2008 on Bridger Creek							
Source category	**BG06**	**BG05**	**BGO4**	**BGO3**	**BGO2**	**BGO1**	**Total**
Subsurface wastewater disposal and treatment	0.01	1.65	0.14	0.92	3.52	9.67	15.91
Forest	0.35	0.83	0.21	1.38	5.28	0.97	9.01
Developed	0.00	1.65	0.21	1.38	3.52	27.43	34.20
Pasture/Rangeland	0.00	1.38	0.83	5.53	22.89	4.83	35.45
Crops	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Urban	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USFWS Fish Tech	0.00	0.00	0.00	0.00	0.00	5.43	5.43
% of peak load	0.36	5.50	1.38	9.21	35.21	48.33	

Natural background was estimated based on flow statistics for the 8/27/2008 sampling event and on data collected from spring sources in the Lyman Creek drainage and in Bridger Creek downstream of the canyon mouth. In addition, the source assessment was reviewed using a multi-year dataset collected at locations above the canyon and near the mouth of Bridger Creek. This analysis determined forest/natural background to be 48% of the $N0_3$+ $N0_2$ load in Bridger Creek. Source categories were adjusted to account for this percentage (**Figure F-12**).

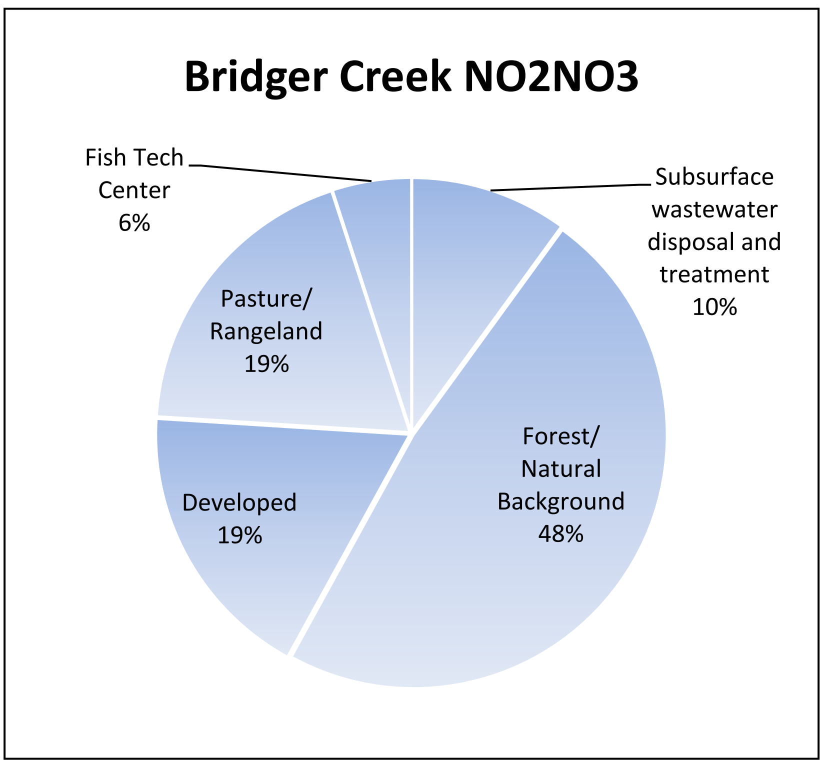

Figure F-12. Existing N03+ N02 sources for Bridger Creek

F.4.3 Camp Creek

Camp Creek is listed as impaired for total phosphorus and total nitrogen on the 2012 303(d) list. Figures and analysis for TP and TN source allocations are provided in this section.

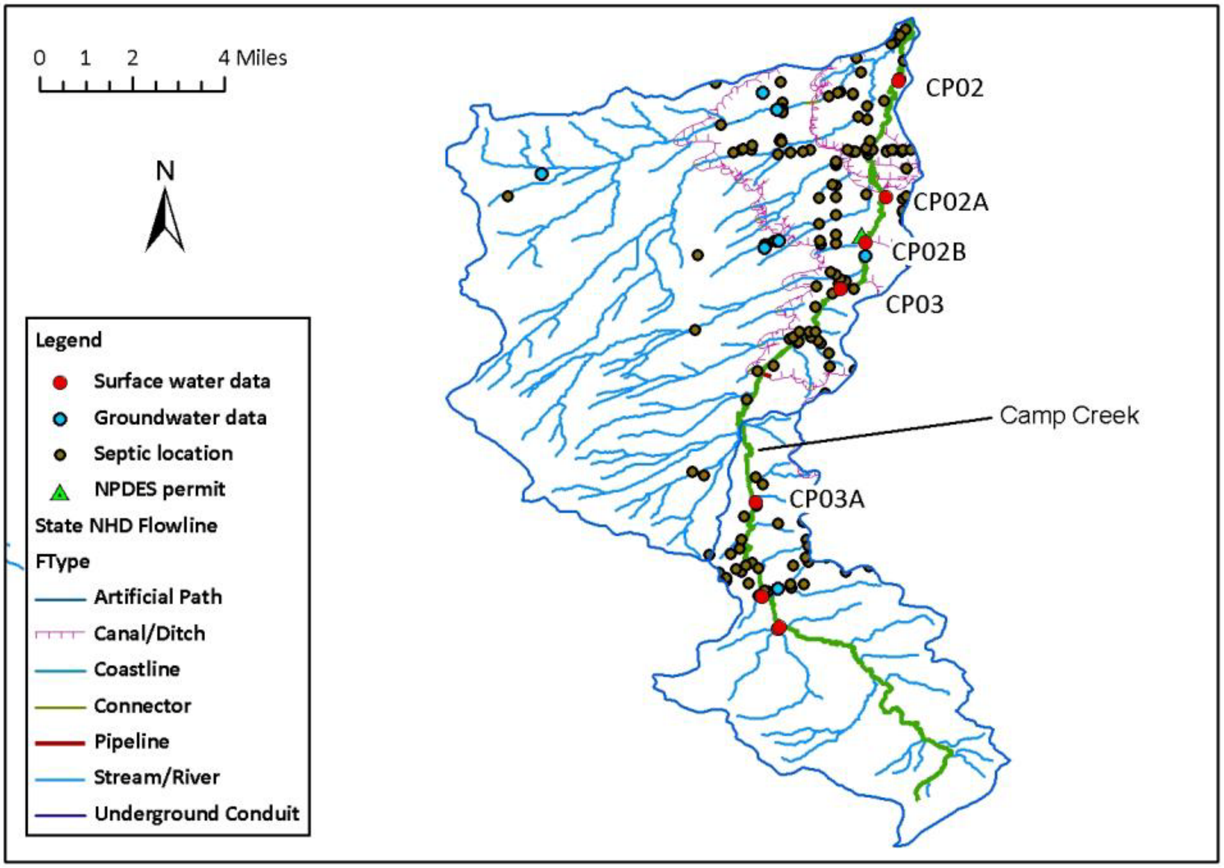

Figure F-13. Spatial data used for the Camp Creek existing load source assessment

Table F-22. Total Nitrogen loading on 9/23/2009 on Camp Creek			
Site ID	**TN load (lbs/day)**	**Change in load from upstream**	**% of peak load**
CP03A	9.01	9.01	6%
CP03	30.23	21.22	14%
CP02B	36.35	6.12	4%
CP02A	37.70	1.35	1%
CP02	151.83	114.12	75%

Table F-23. Existing load source assessment for Total Nitrogen on 9/23/2009 on Camp Creek						
Source category	**CP03A**	**CP03**	**CP02B**	**CP02A**	**CP02**	**Total**
Subsurface wastewater disposal and treatment	0.59	0.84	0.40	0.04	10.52	12.39
Forest	0.00	0.00	0.00	0.00	0.00	0.00
Developed	0.00	1.40	1.61	0.09	7.52	10.62
Pasture/Rangeland	3.86	4.47	1.01	0.22	8.27	17.83
Crops	1.48	7.27	1.01	0.54	48.86	59.16
Urban	0.00	0.00	0.00	0.00	0.00	0.00
% of peak load	5.93	13.98	4.03	0.89	75.17	

Natural background was determined to be 15% of the TN load. Source categories were adjusted to account for this percentage (**Figure F-14**).

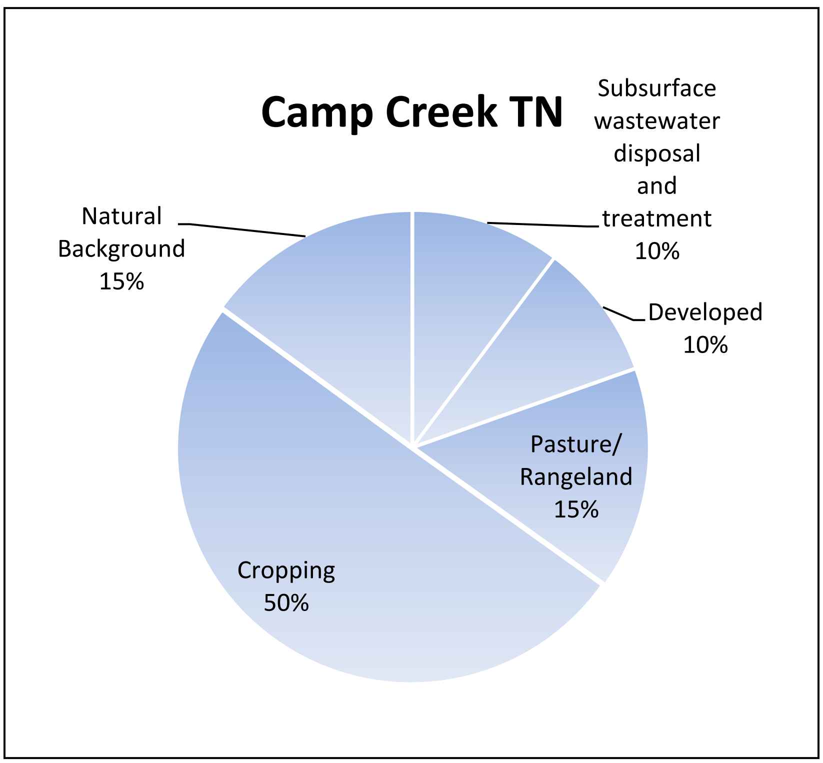

Figure F-14. Existing TN sources for Camp Creek

Table F-24. Total Phosphorus loading on 9/23/2009 on Camp Creek			
Site ID	**TP load (lbs/day)**	**Change in load from upstream**	**% of peak load**
CP03A	0.59	0.59	22%
CP03	1.80	1.21	46%
CP02B	2.00	0.20	8%
CP02A	2.16	0.16	6%
CP02	2.65	0.49	18%

Table F-25. Existing load source assessment for Total Phosphorus on 9/23/2009 on Camp Creek						
Source category	**CP03A**	**CP03**	**CP02B**	**CP02A**	**CP02**	**Total**
Subsurface wastewater disposal and treatment	1.11	1.38	0.38	2.26	1.83	6.96
Forest	0.00	0.00	0.00	0.00	0.00	0.00
Developed	0.00	4.59	2.30	0.59	2.75	10.24
Pasture/Rangeland	15.51	27.54	4.22	1.90	3.67	52.84
Crops	5.54	12.39	0.77	1.19	10.09	29.97
Urban	0.00	0.00	0.00	0.00	0.00	0.00
% of peak load	22.16	45.90	7.67	5.94	18.34	

Natural background was determined to be 30% of the TP load. Source categories were adjusted to account for this percentage (**Figure F-15**).

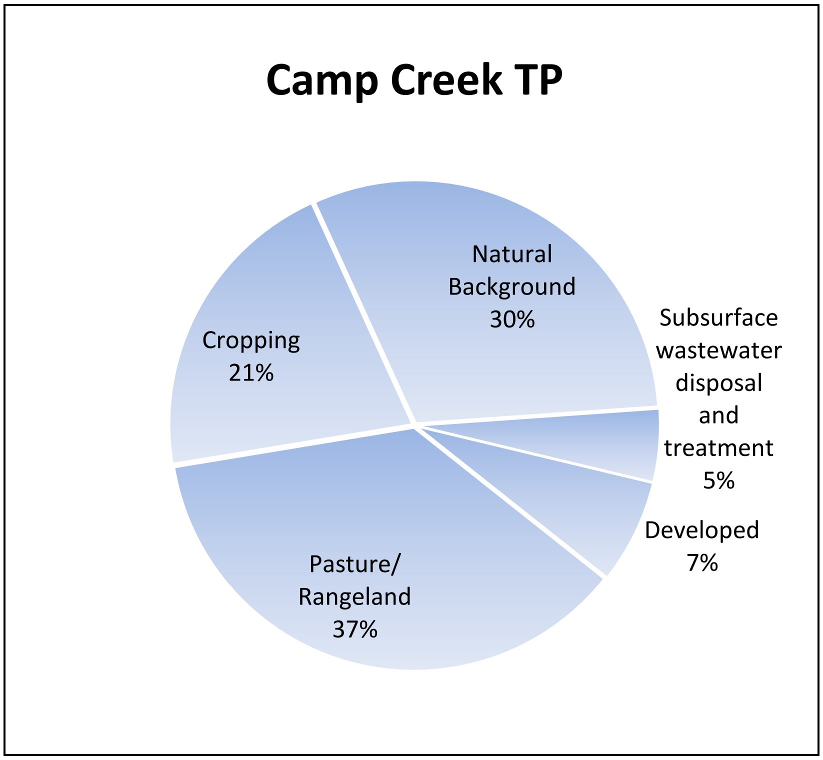

Figure F-15. Existing TP sources for Camp Creek

E.4.4 Dry Creek

Dry Creek is listed as impaired for total phosphorus and total nitrogen on the 2012 303(d) list. Figures and analysis for TP and TN source allocations are provided in this section.

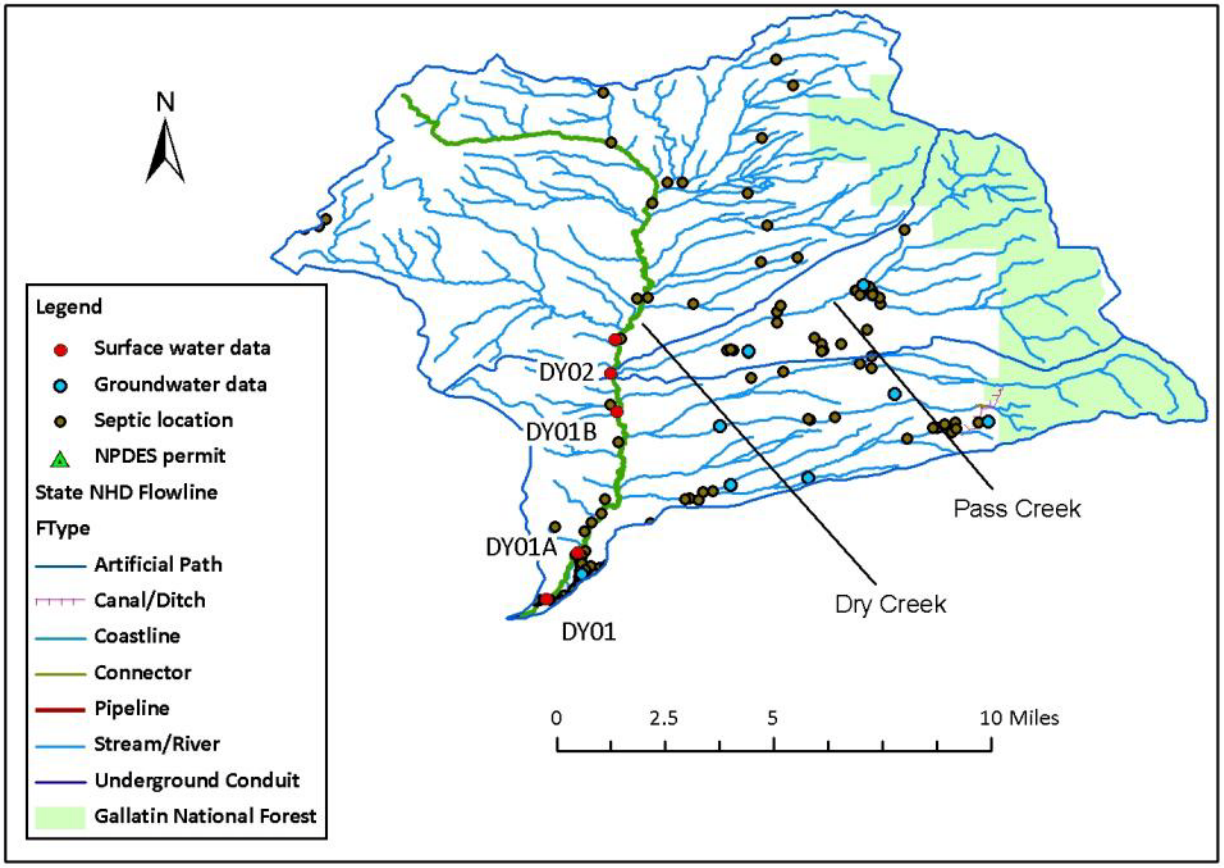

Figure F-16. Spatial data used for the Dry Creek existing load source assessment

Table F-26. Total Nitrogen loading on 9/21/09 on Dry Creek			
Site ID	**TP load (lbs/day)**	**Change in load from upstream**	**% of peak load**
DY02	8.32	8.32	16%
DY01B	45.90	37.58	74%
DY01A	23.25	-22.65	NA
DY01	28.43	5.18	10%

Table F-27. Existing load source assessment for Total Nitrogen on 9/21/2009 on Dry Creek					
Source category	**DY02**	**DY01B**	**DY01A**	**DY01**	**Total**
Subsurface wastewater disposal and treatment	0.16	4.43		3.05	7.64
Forest	0.49	4.43		0.00	4.92
Developed	0.16	0.74		1.53	2.43
Pasture/Rangeland	10.61	23.60		2.54	36.76
Crops	5.06	41.31		3.05	49.42
Urban	0.00	0.00		0.00	0.00
% of peak load	16.49	74.50		10.17	

Analysis of flow data and MDEQ reference data determined natural background to be 14% of the Total Nitrogen load in Dry Creek. Source categories were adjusted to account for this percentage (**Figure F-17**).

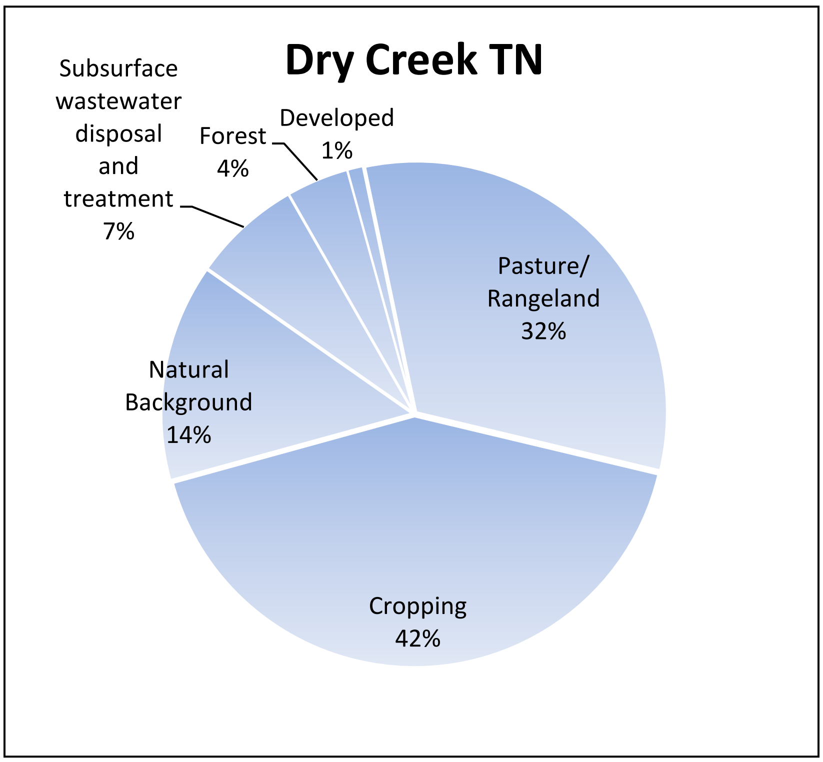

Figure F-17. Existing TN sources for Dry Creek

Table F-28. Total Phosphorus loading on 9/21/09 on Dry Creek			
Site ID	**TP load (lbs/day)**	**Change in load from upstream**	**% of peak load**
DY02	0.55	0.55	0.44
DY01B	1.16	0.61	0.49
DY01A	1.18	0.02	0.02
DY01	1.24	0.06	0.05

Table F-29. Existing load source assessment for Total Phosphorus on 9/21/2009 on Dry Creek					
Source category	**DY02**	**DY01B**	**DY01A**	**DY01**	**Total**
Subsurface wastewater disposal and treatment	0.00	3.44	0.08	0.24	3.77
Forest	2.22	1.97	0.00	0.00	4.19
Developed	7.10	8.85	0.32	0.97	17.24
Pasture/Rangeland	21.73	19.68	0.68	2.03	44.12
Crops	13.31	15.25	0.53	1.60	30.69
Urban	0.00	0.00	0.00	0.00	0.00
% of peak load	44.35	49.19	1.61	4.84	

Analysis of flow data and MDEQ reference data determined natural background to be 48% of the Total Nitrogen load in Dry Creek. Source categories were adjusted to account for this percentage (**Figure F-18**).

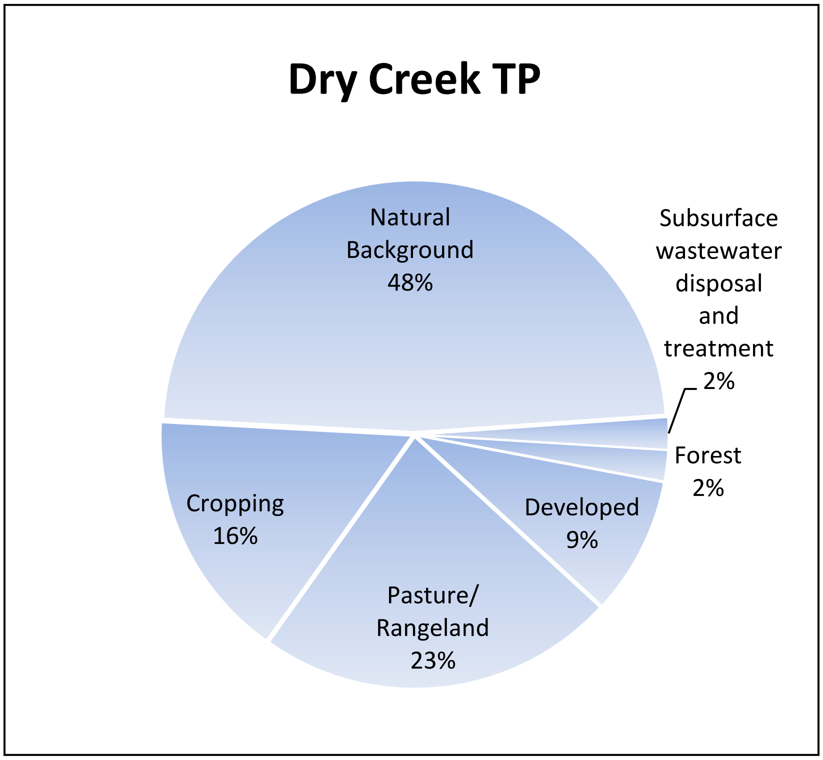

Figure F-18. Existing TP sources for Dry Creek

F.4.5 Lower Hyalite Creek

The lower segment of Hyalite Creek below the forest boundary is listed as impaired for total nitrogen on the 2012 303(d) list. Figures and analysis for TN source allocations are provided in this section.

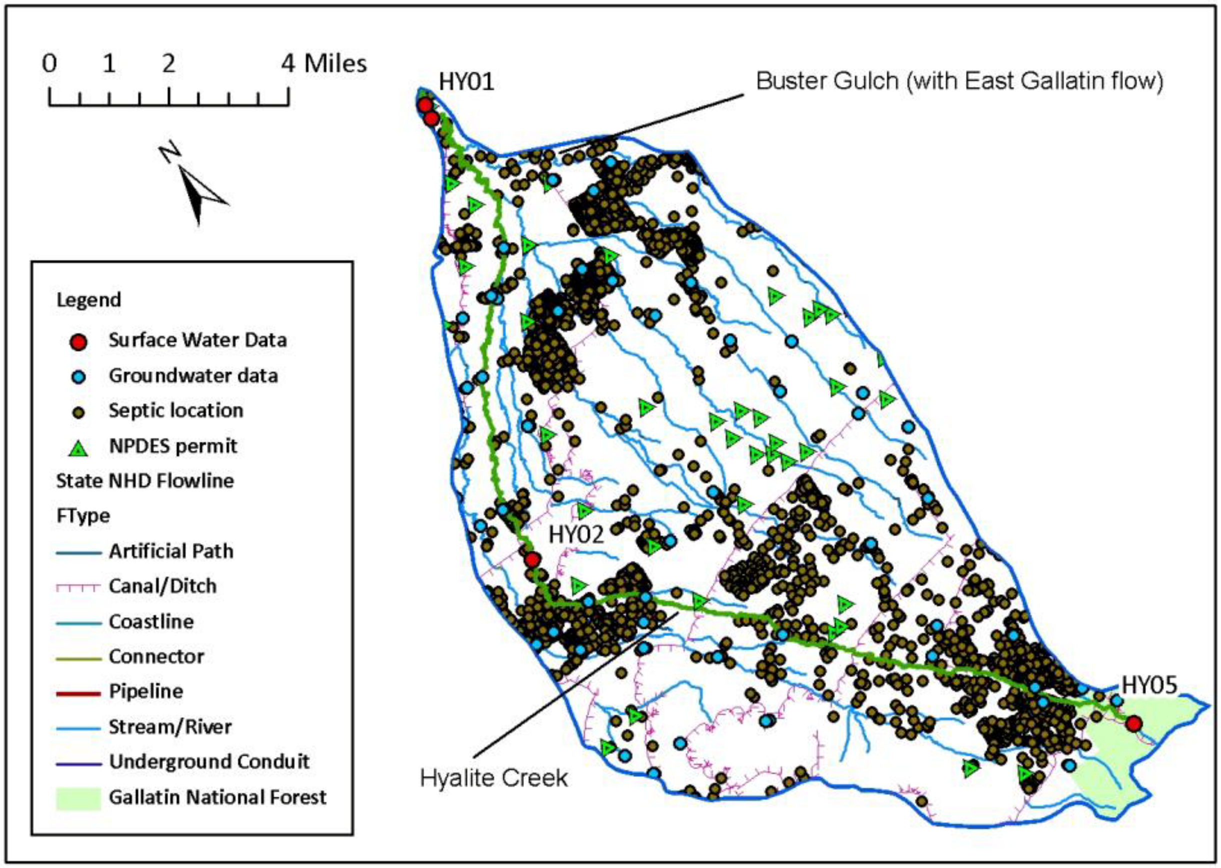

Figure F-19. Spatial data used for lower Hyalite Creek existing load source assessment

A complete synoptic sampling event was completed on Hyalite Creek on 9/14/2009 from the upper segment to the mouth (**Table F-30**). This provided relative load and flow data for calculating forest and natural background TN loads from above the forest boundary. Sites upstream of HY05 are not displayed in **Figure F-19** as they are in the middle and upper Hyalite Creek assessment units.

Table F-30. Total Nitrogen loading on 9/14/2009 Hyalite Creek

Hyalite Creek AU	Site ID	TN Load (lbs/day)	Change in load from upstream	% of peak load
UPPER	**HY08**	4.68	4.68	2%
MIDDLE	**HY04**	52.41	47.73	15%
MIDDLE	**HY03**	51.72	-0.69	NA
LOWER	**HY05**	42.03	-9.70	NA
LOWER	**HY02**	22.75	-19.28	NA
LOWER	**HY01**	285.85	263.10	83%

Flow data from the sampling event indicate the impacts of irrigation and water supply diversions from Hyalite Creek in the lower segment (**Table F-31**).

Table F-31. Discharge at sampled locations on 9/14/2009 Hyalite Creek	
Site ID	**Discharge (cfs)**
HY08	9.68
HY04	61.0
HY03	68.8
HY05	65.22
HY02	6.62
HY01	27.87

For the source assessment using the 9/14/2009 data, the load to Hyalite Creek via Buster Gulch was omitted as that source is being address by a different TMDL on the middle segment of the East Gallatin River (**Table F-32**).

Table F-32. Total Nitrogen loading on 9/14/09 on Lower Hyalite Creek			
Site ID	**TP load (lbs/day)**	**Change in load from upstream**	**% of peak load**
HY05	42.03	42.03	18%
HY02	22.75	-19.28	NA
HY01	209.24	186.49	82%

Table F-33. Existing load source assessment for Total Nitrogen on 9/14/2009 Lower Hyalite Creek				
Source category	**HY05**	**HY02**	**HY01**	**Total**
Subsurface wastewater disposal and treatment			34.74	34.74
Forest	13.74			13.74
Developed			10.17	10.17
Pasture/Rangeland	1.53		19.49	21.02
Crops			20.34	20.34
Urban			34.74	34.74
% of peak load	14.20		85.80	

Based on water quality data collected above the forest boundary and the MDEQ reference dataset, natural background in Lower Hyalite Creek was determined to be 14% of the existing TN load. Source categories were adjusted to account for this percentage (**Figure F-20**). **Figure F-20** reflects the existing source assessment for Lower Hyalite Creek without the TN load and source assessment from the load transported to Hyalite Creek from the East Gallatin River via Buster Gulch. Buster Gulch flows into

Hyalite Creek ~ 1 mile above the mouth (East Gallatin River) and has little impact on the overall water quality of the reach which is 21 miles in length.

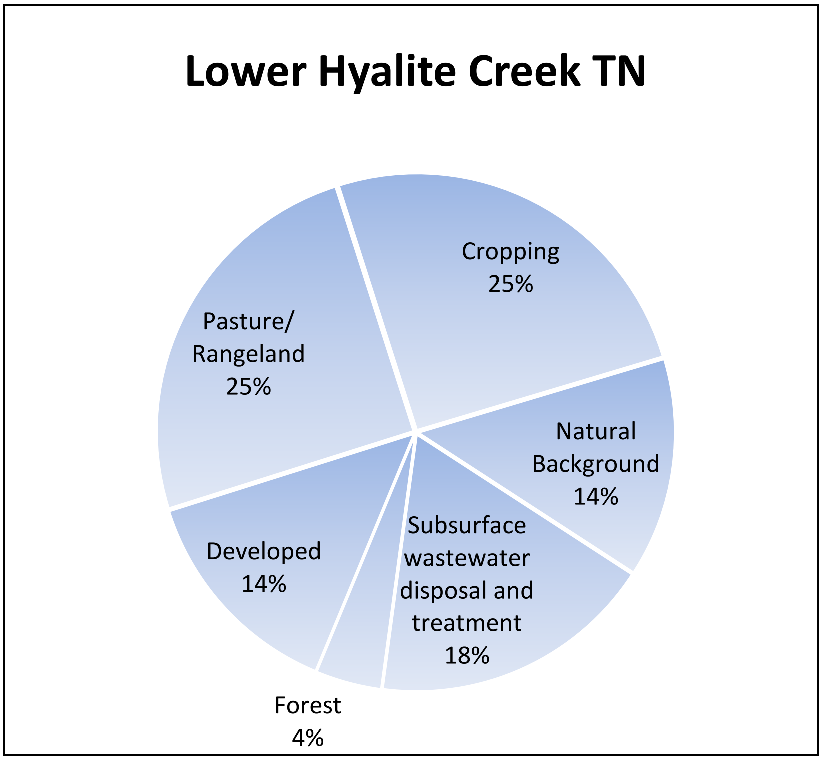

Figure F-20. Existing TN sources for Lower Hyalite Creek

F.4.6 Jackson Creek

Jackson Creek is listed as impaired for total phosphorus on the 2012 303(d) list. Figures and analysis for TP source allocations are provided in this section.

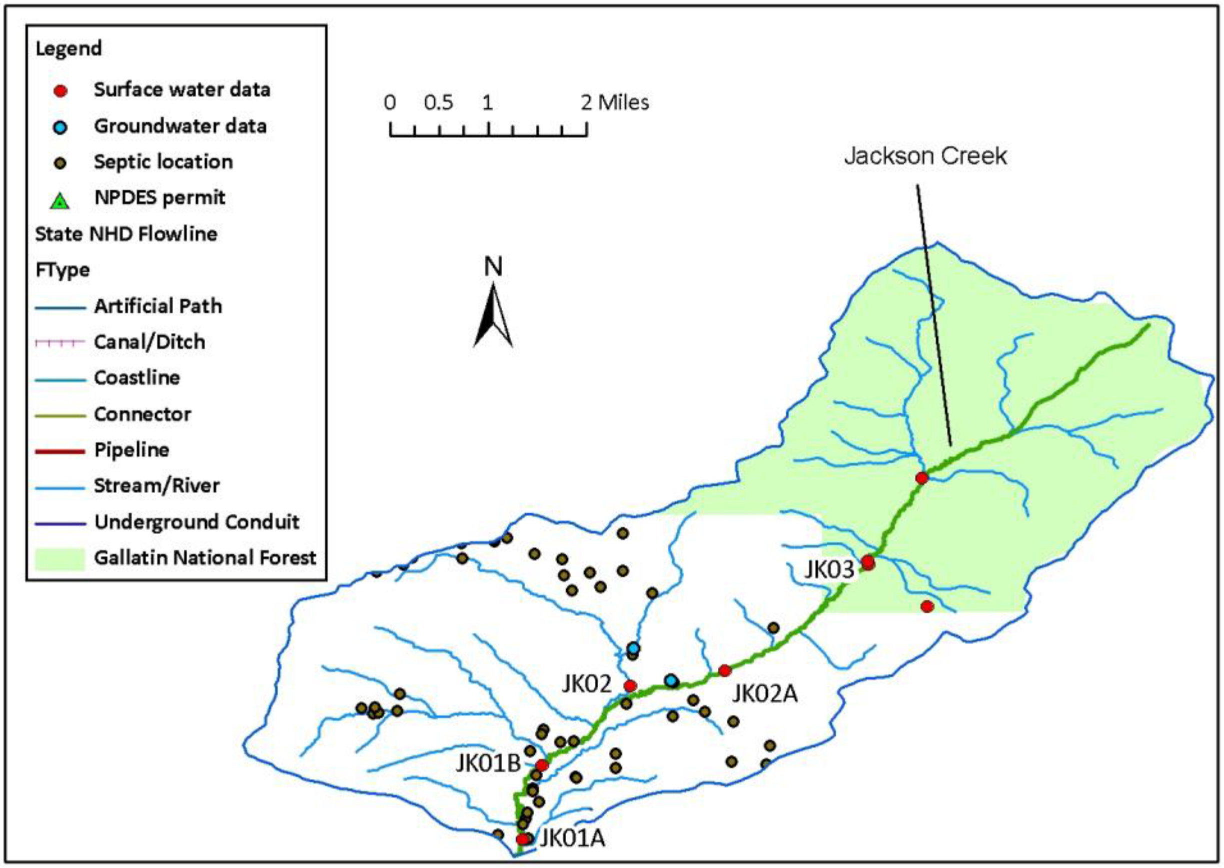

Figure F-21. Spatial data used for the Jackson Creek existing load source assessment

Table F-34. Total Phosphorus loading on 8/28/2008 on Jackson Creek

Site ID	TP load (lbs/day)	Change in load from upstream	% of peak load
JK03	0.09	0.09	0.21
JK02	0.44	0.34	0.79

Table F-35. Existing load source assessment for Total Phosphorus on 8/28/2008 on Jackson Creek			
Source category	**JK03**	**JK02**	**Total**
Subsurface wastewater disposal and treatment	0.00	0.00	0.00
Forest	13.90	7.86	21.76
Developed	4.28	11.79	16.07
Pasture/Rangeland	3.21	58.97	62.17
Crops	0.00	0.00	0.00
Urban	0.00	0.00	0.00
% of peak load	21.38	78.62	

Table F-36. Total Phosphorus loading on 9/18/2009 on Jackson Creek			
Site ID	**TP load (lbs/day)**	**Change in load from upstream**	**% of peak load**
JK02A	0.08	0.08	33%
JK01B	0.18	0.09	36%
JK01A	0.26	0.08	31%

Table F-37. Existing load source assessment for Total Phosphorus on 9/18/2009 on Jackson Creek				
Source category	**JK02A**	**JK01B**	**JK01A**	**Total**
Subsurface wastewater disposal and treatment	0.00	1.82	1.54	3.36
Forest	26.20	1.82	0.00	28.02
Developed	4.91	1.82	0.00	6.74
Pasture/Rangeland	1.64	31.01	29.23	61.88
Crops	0.00	0.00	0.00	0.00
Urban	0.00	1.82	1.54	0.00
% of peak load	32.75	36.49	30.76	

Mean percentages from the 2 sampling date analyses were calculated for the Jackson Creek existing load assessment which did not include natural background. Natural background was estimated based on flow statistics for the 8/27/2008 and 9/18/2009 sampling events and the median natural background concentration for TP in the ecoregions which comprise the Jackson Creek basin. This method determined natural background to be 13% of the TP load in Jackson Creek. Source categories were adjusted to account for this percentage (**Figure F-22**).

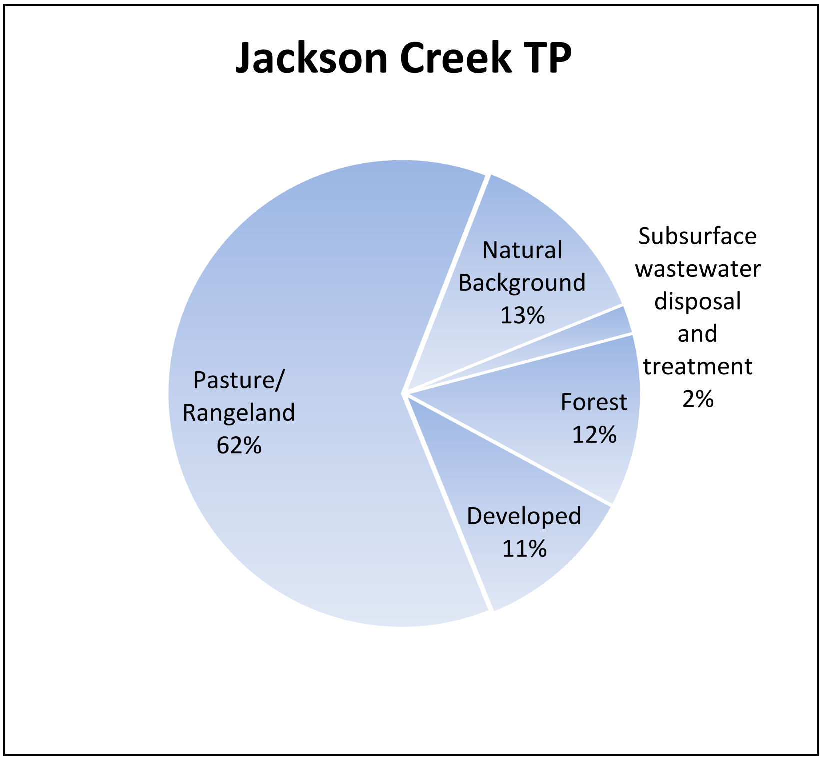

Figure F-22. Existing TP sources for Jackson Creek

F.4.7 Mandeville Creek

Mandeville Creek is impaired for total phosphorus and total nitrogen based on available water quality data. Mandeville Creek does not appear on the 2012 303(d) list but will be added to the 2014 303(d) list. Figures and analysis for TP and TN source allocations are provided in this section.

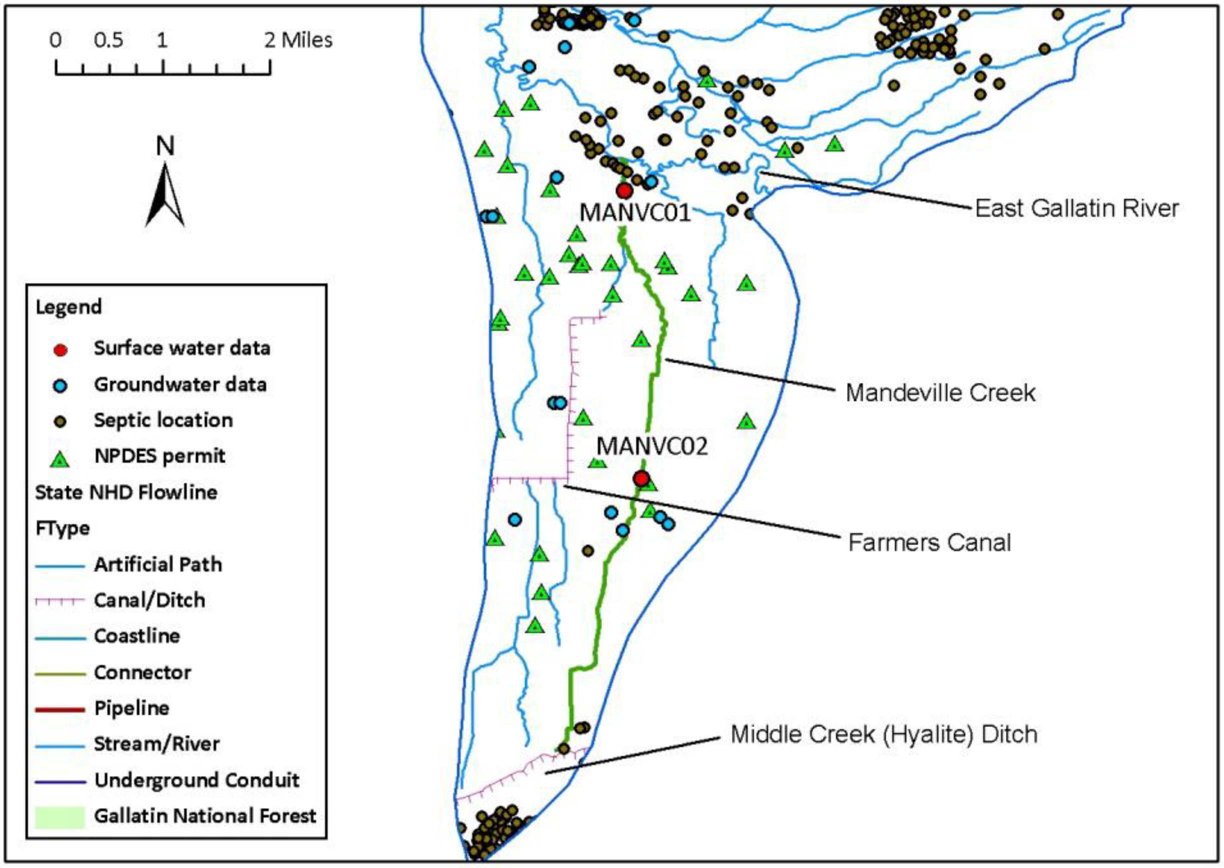

Figure F-23. Spatial data used for the Mandeville Creek existing load source assessment

Mandeville Creek was sampled at both sample locations in 9 separate events from 2009-2011. The complete dataset was analyzed to determine the relative total load contributions are each sampling point. For Total Nitrogen, 22.9% of the TN load was observed at MANCOV2 and 77.1% was observed at the downstream location MANCOV1 on average. These relative percentages were used to determine the existing source allocation. Natural background was determined to be 6% of the TN load. Source categories were adjusted to account for this percentage (**Figure F-24**).

Table F-38. Existing load source assessment for Total Nitrogen for Mandeville Creek			
Source category	**MANCOV2**	**MANCOV1**	**Total**
Subsurface wastewater disposal and treatment	0.00	2.31	2.31
Forest	0.00	0.00	0.00
Developed	3.44	23.13	26.57
Pasture/Rangeland	2.29	11.57	13.86
Crops	17.18	24.67	41.85
Urban	0.00	15.42	15.42
% of peak load	22.90	77.10	

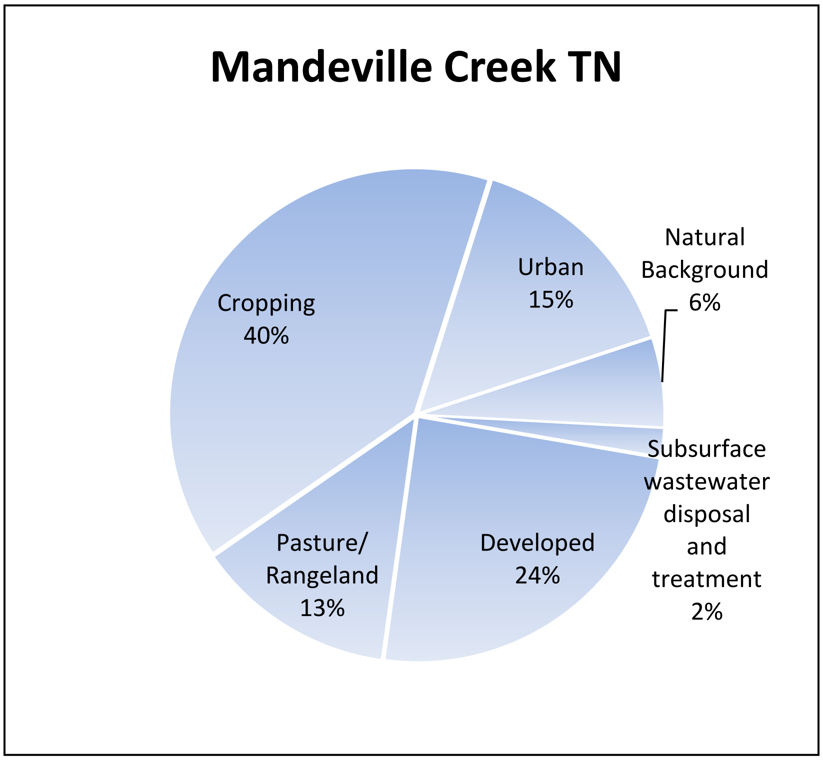

Figure F-24. Existing TN sources for Mandeville Creek

Analyzing the available dataset for Total Phosphorus, 19.9% of the TP load was observed at MANCOV2 and 80.1% was observed at the downstream location MANCOV1 on average. These relative percentages were used to determine the existing source allocation. Natural background was determined to be 8% of the TP load. Source categories were adjusted to account for this percentage (**Figure F-25**).

Table F-39. Existing load source assessment for Total Phosphorus for Mandeville Creek			
Source category	**MANCOV2**	**MANCOV1**	**Total**
Subsurface wastewater disposal and treatment	0.00	0.80	0.80
Forest	0.00	0.00	0.00
Developed	2.99	28.04	31.02
Pasture/Rangeland	3.98	16.02	20.00
Crops	12.94	16.02	28.96
Urban	0.00	19.22	19.22
% of peak load	19.90	80.10	

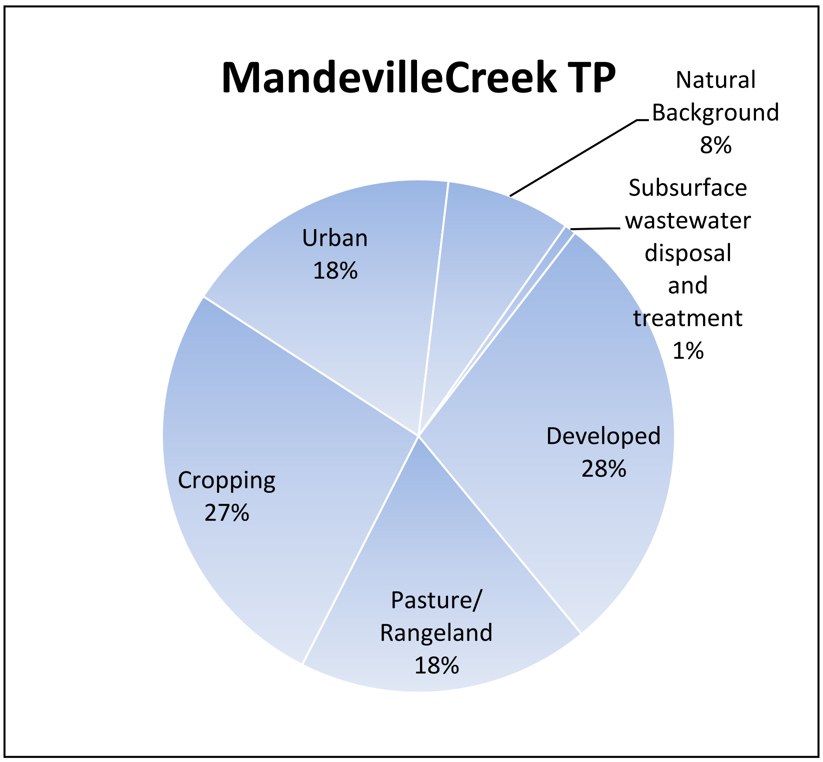

Figure F-25. Existing TP sources for Mandeville Creek

F.4.8 Reese Creek

Reese Creek is listed as impaired for total nitrogen and nitrite+nitrate ($N0_3$+ $N0_2$) on the 2012 303(d) list. Figures and analysis for TN and $N0_3$+ $N0_2$ source allocations are provided in this section.

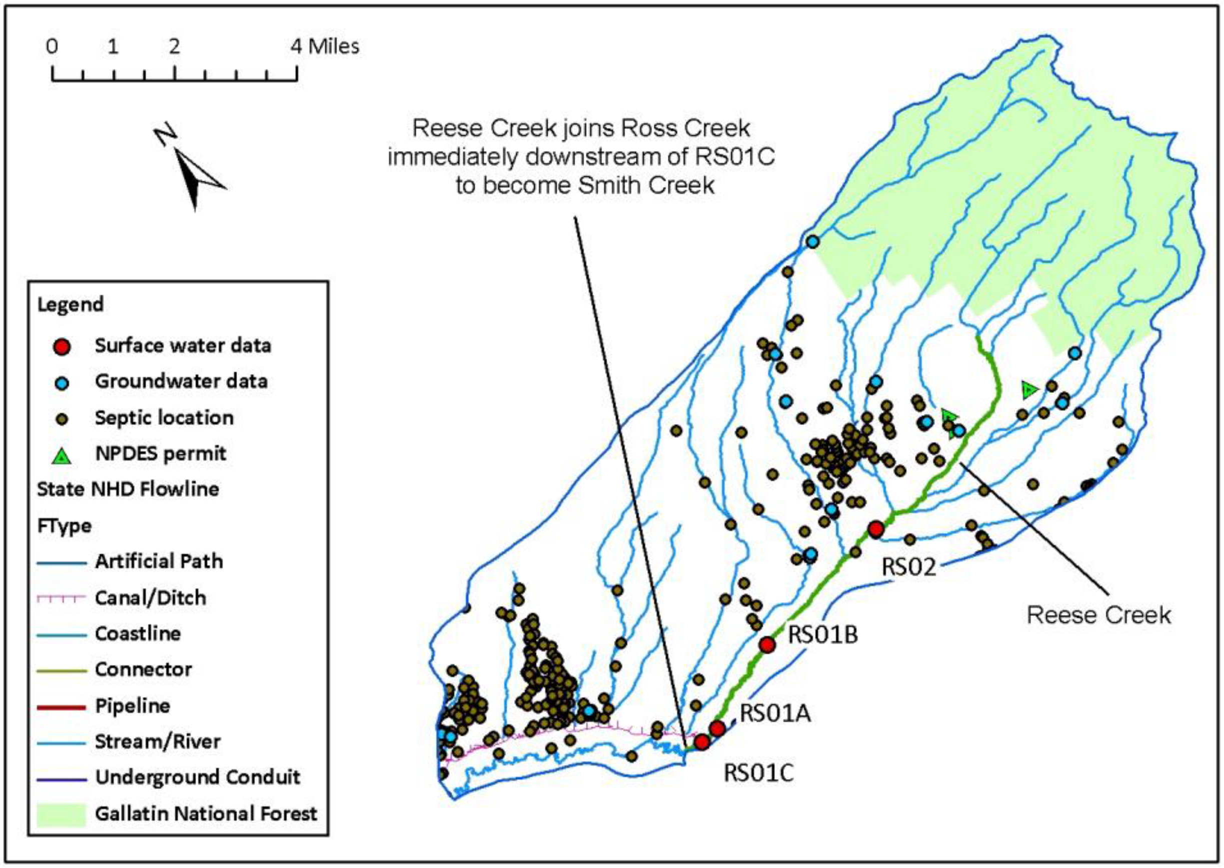

Figure F-26. Spatial data used for the Reese Creek existing load source assessment

Table F-40. Total Nitrogen loading on 9/17/2009 on Reese Creek			
Site ID	**TP load (lbs/day)**	**Change in load from upstream**	**% of peak load**
RS02	20.06	20.06	0.50
RS01B	40.06	20.01	0.50
RS01A	26.98	-13.08	NA
RS01C	18.61	-8.38	NA

Table F-41. Existing load source assessment for Total Nitrogen on 9/17/2009 on Reese Creek					
Source category	**RS02**	**RS01B**	**RS01A**	**RS01C**	**Total**
Subsurface wastewater disposal and treatment	3.50	7.50			11.00
Forest	12.50	11.50			24.00
Developed	0.00	0.50			0.50
Pasture/Rangeland	17.50	12.00			29.50
Crops	16.50	18.50			35.00
Urban	0.00	0.00			0.00
% of peak load	50.00	50.00			

For natural background, water quality data collected by the MBMG above the forest boundary was used to estimate the natural background load in Reese Creek and was incorporated into the source assessment methodology outlined in **Table F-41.** Source categories were adjusted to account for this percentage (**Figure F-27**).

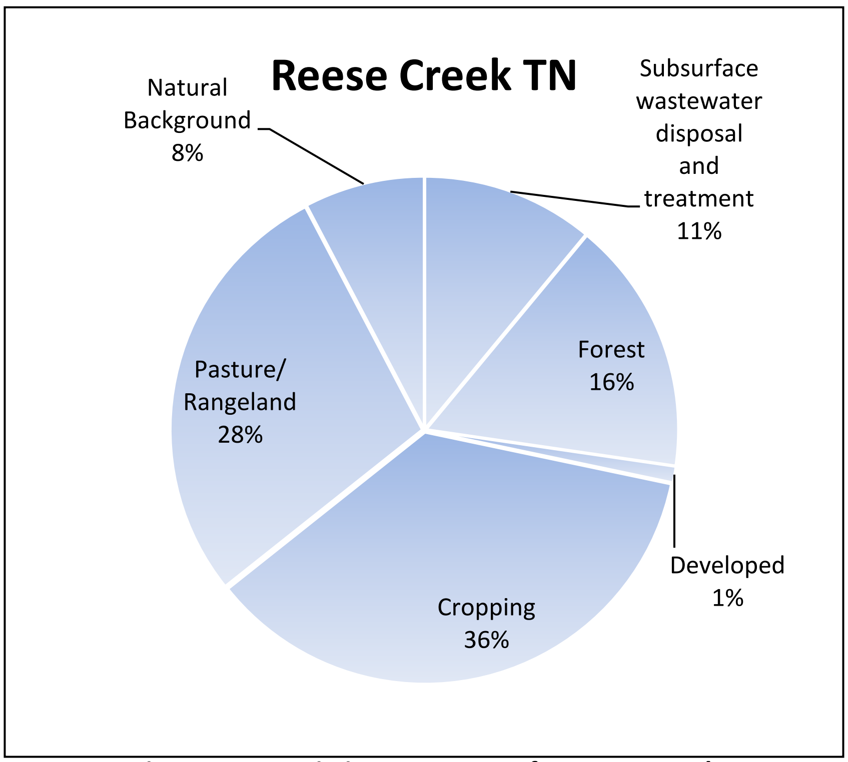

Figure F-27. Existing TN sources for Reese Creek

Table F-42. N03+ N02 loading on 9/17/2009 on Reese Creek			
Site ID	**TP load (lbs/day)**	**Change in load from upstream**	**% of peak load**
RS02	15.03	12.96	40%
RS01B	34.26	19.22	60%
RS01A	22.75	-11.50	NA
RS01C	14.69	-8.06	NA

Table F-43. Existing load source assessment for N03+ N02 on 9/17/2009 on Reese Creek					
Source category	**RS02**	**RS01B**	**RS01A**	**RS01C**	**Total**
Subsurface wastewater disposal and treatment	2.01	5.38			7.39
Forest	16.11	22.70			38.81
Developed	14.10	20.31			34.41
Pasture/Rangeland	0.00	0.60			0.60
Crops	8.06	10.75			18.81
Urban	2.01	5.38			7.39
% of peak load	40.28	59.74			

For natural background, water quality data collected by the MBMG above the forest boundary was used to estimate the natural background load in Reese Creek and was incorporated into the source assessment methodology outlined in **Table F-43.** Source categories were adjusted to account for this percentage (**Figure F-28**).

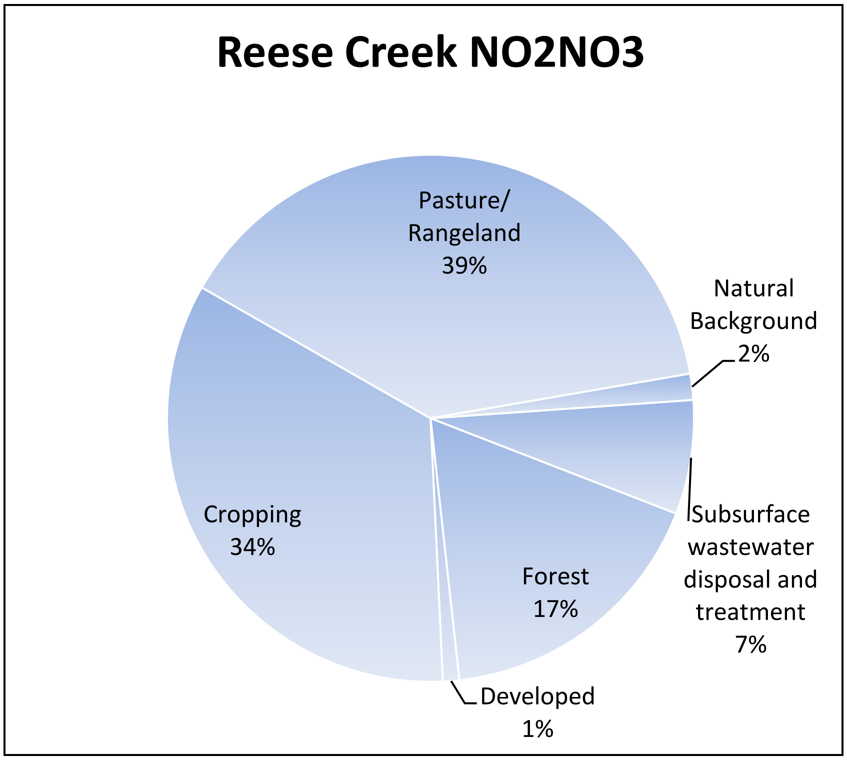

Figure F-28. Existing N03+ N02 sources for Reese Creek

F.4.9 Smith Creek

Smith Creek is listed as impaired for total nitrogen and nitrite+nitrate ($N0_3$+ $N0_2$) on the 2012 303(d) list. Figures and analysis for TN and $N0_3$+ $N0_2$ source allocations are provided in this section.

Smith Creek presented an interesting case where an irrigation canal conveyed East Gallatin River water to the Smith Creek drainage. The Dry Creek Irrigation Canal flows northward from the East Gallatin River and intersects Ross Creek (**Figure F-29**). At this point, flows from the canal and Ross Creek continue northward in the same channel. Ross Creek originally continued northeastward to its confluence with Smith Creek but is now channelized along a private road to where it meets Reese Creek. At this intersection of flow, Ross Creek/Dry Creek Irrigation Canal flow up from the south and join Reese Creek from the east. The Dry Creek Irrigation Canal continues northward. The confluence marks the start of Smith Creek which flows westward to the East Gallatin River. As there is not a headgate or diversion that separates flows at this intersection, water quality analyses assumed that during the summer period Reese Creek flows are forced into the Dry Creek Irrigation Canal which flows northward with a mix of Ross Creek, Reese Creek and East Gallatin River flows. Smith Creek flows westward with a mixture of Ross Creek and East Gallatin River flow. Under this assumption, the Reese Creek watershed is not a source area of nutrient impairments on Smith Creek during the summer period when the irrigation canal is flowing. The nutrient load from the East Gallatin River was included in the analyses because it impacts the entire length of Smith Creek.

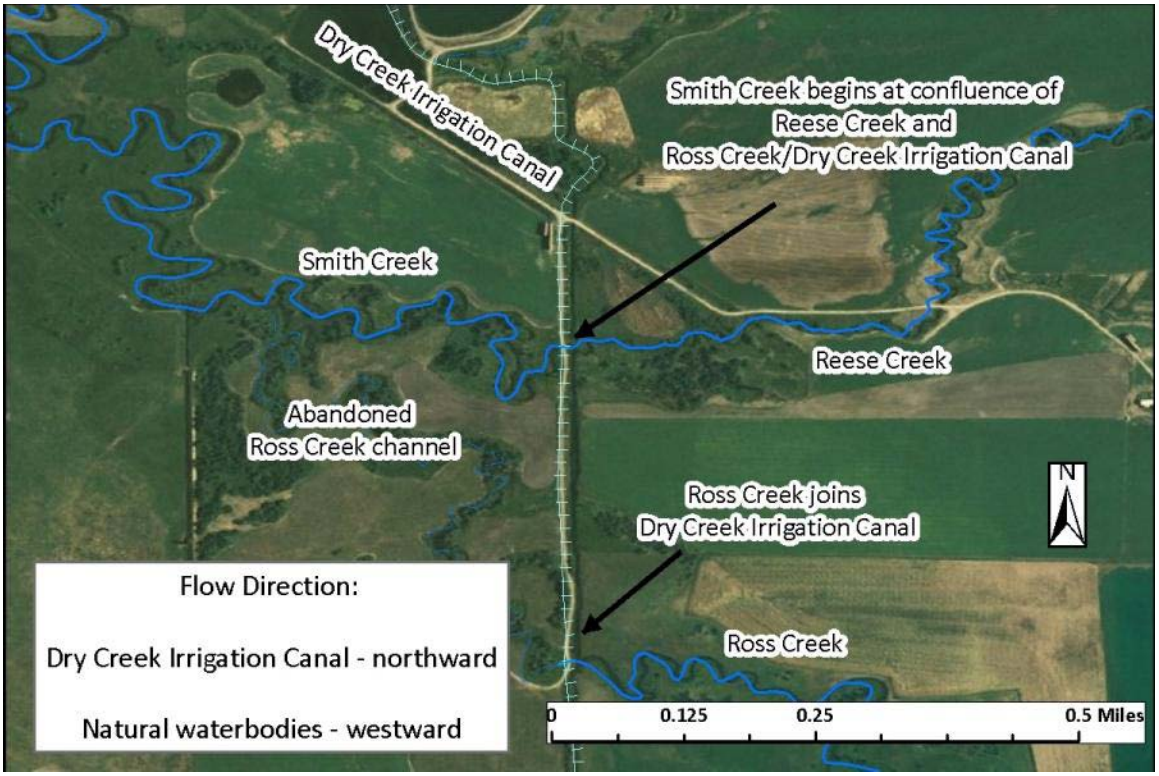

Figure F-29. Confluence of Ross, Reese, and Smith Creeks and influence of Dry Creek Irrigation Canal

The source assessment of the existing load used data collected on the East Gallatin River as well as the Ross Creek drainage. **Figure F-30** displays only those sample locations on Smith Creek.

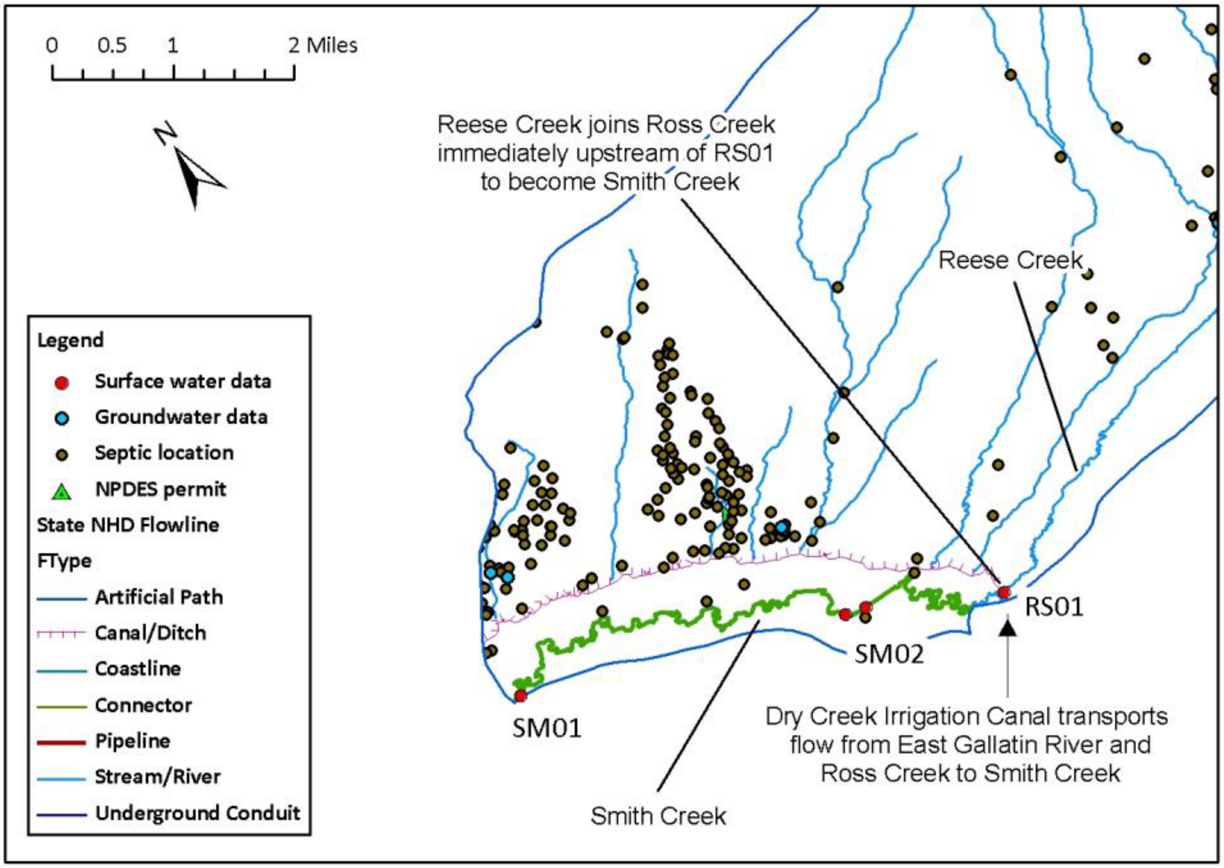

Figure F-30. Spatial data used for the Smith Creek existing load source assessment

Flow and load analyses determined that 63% of the load in Smith Creek originated from the East Gallatin River and 37% from the Ross Creek drainage. TN loads did not increase in the Smith Creek basin between sampling points.

Table F-44. Existing load source assessment for Total Nitrogen on 9/17/2009 on Smith Creek				
Source category	**From East Gallatin River**	**From Ross Creek drainage**	**From Smith Creek drainage**	**Total**
Subsurface wastewater disposal and treatment	10.70	0.32		11.03
Forest	3.15	3.42		6.57
Developed	2.52	0.00		2.52
Pasture/Rangeland	11.34	10.45		21.79
Crops	11.34	22.80		34.14
Urban	23.93	0.00		23.93
% of peak load	62.99	37.00		

For natural background, water quality data collected by the MBMG above the forest boundary was used to estimate the natural background load in Ross Creek and was incorporated into the source assessment methodology outlined in **Table F-44** for Smith Creek**.** Natural background was determined for the East Gallatin River assessment. Source categories were adjusted to account for this percentage (**Figure F-31**).

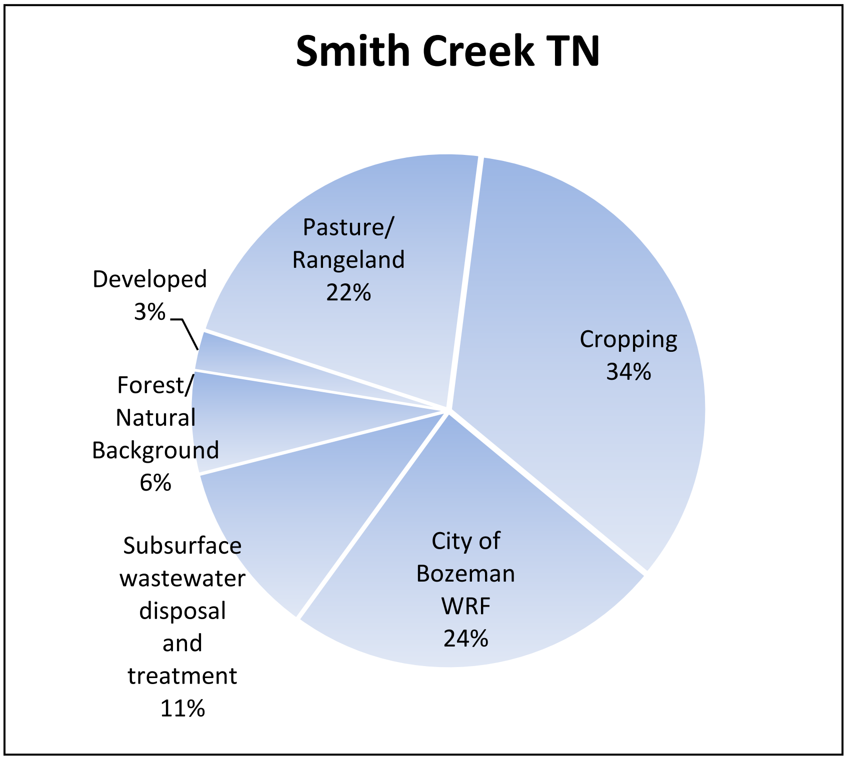

Figure F-31. Existing TN sources for Smith Creek

Flow and load analyses determined that 61% of the load in Smith Creek originated from the East Gallatin River and 39% from the Ross Creek drainage. TN loads did not increase in the Smith Creek basin between sampling points.

Table F-45. Existing load source assessment for NO2NO3 on 9/17/2009 on Smith Creek				
Source category	**From East Gallatin River**	**From Ross Creek drainage**	**From Smith Creek drainage**	**Total**
Subsurface wastewater disposal and treatment	6.66	0.20		6.86
Forest	2.90	3.15		6.05
Developed	2.46	0.00		2.46
Pasture/Rangeland	15.45	14.24		29.69
Crops	10.47	21.10		31.58
Urban	0.00	0.00		0.00
City of Bozeman WRF	23.41	0.00		23.41
% of peak load	61.35	38.70		

For natural background, water quality data collected by the MBMG above the forest boundary was used to estimate the natural background load in Ross Creek and was incorporated into the source assessment methodology outlined in **Table F-45** for Smith Creek**.** Natural background was determined for the East Gallatin River assessment. Source categories were adjusted to account for this percentage (**Figure F-32**).

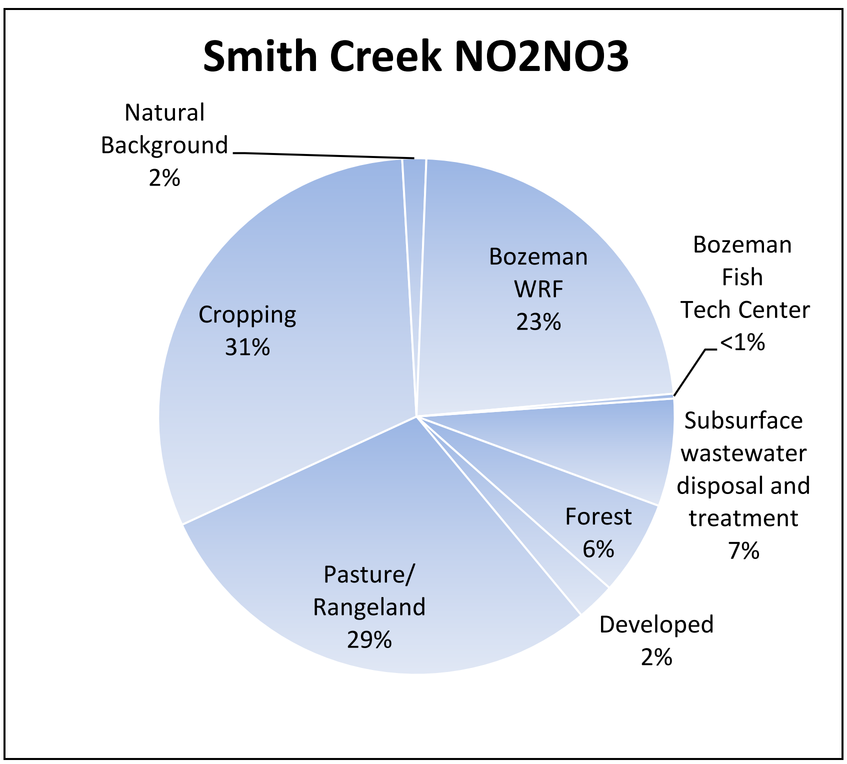

Figure F-32. Existing N03+ N02 sources for Smith Creek

F.4.10 Thompson Creek

Thompson Creek is listed as impaired for total nitrogen on the 2012 303(d) list. Figures and analysis for TN source allocations are provided in this section.

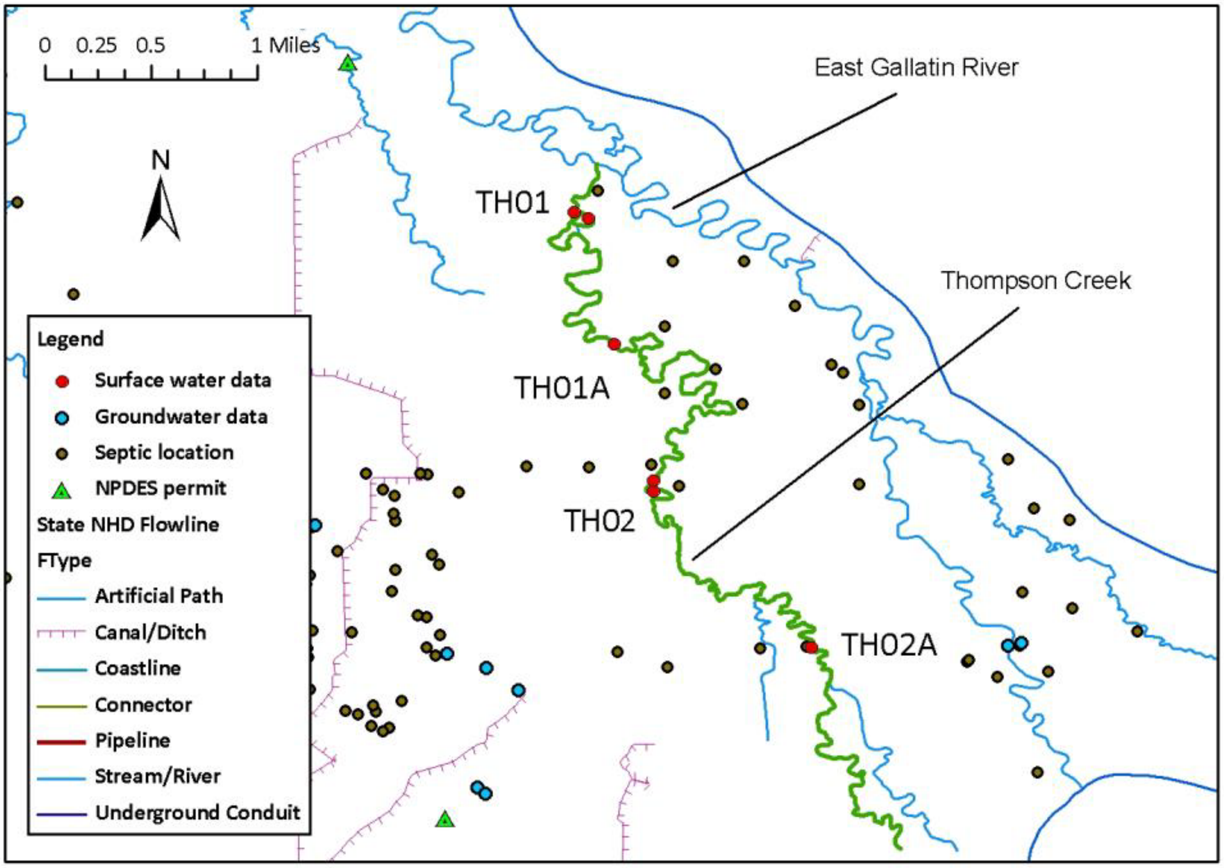

Figure F-33. Spatial data used for the Thompson Creek existing load source assessment

Table F-46. TN loading on 9/21/2009 on Thompson Creek			
Site ID	**TP load (lbs/day)**	**Change in load from upstream**	**% of peak load**
TH02A	16.54	16.54	18%
THO2	43.51	26.97	30%
THO1A	88.57	45.06	50%
THO1	89.49	0.92	1%

Table F-47. Existing load source assessment for TN on 9/21/2009 on Thompson Creek					
Source category	**TH02A**	**THO2**	**THO1A**	**THO1**	**Total**
Subsurface wastewater disposal and treatment	0.37	0.90	1.01	0.00	2.28
Forest	0.00	0.00	0.00	0.00	0.00
Developed	0.18	1.81	3.52	0.04	5.56
Pasture/Rangeland	7.76	13.56	19.64	0.36	41.32
Crops	10.16	13.86	26.18	0.53	50.74
Urban	0.00	0.00	0.00	0.00	0.00
% of peak load	18.48	30.14	50.35	0.93	

Natural background was calculated using flow statistics and MDEQ reference data. Natural background was calculated as 11% of the existing load. Source categories were adjusted to account for this percentage (**Figure F-34**).

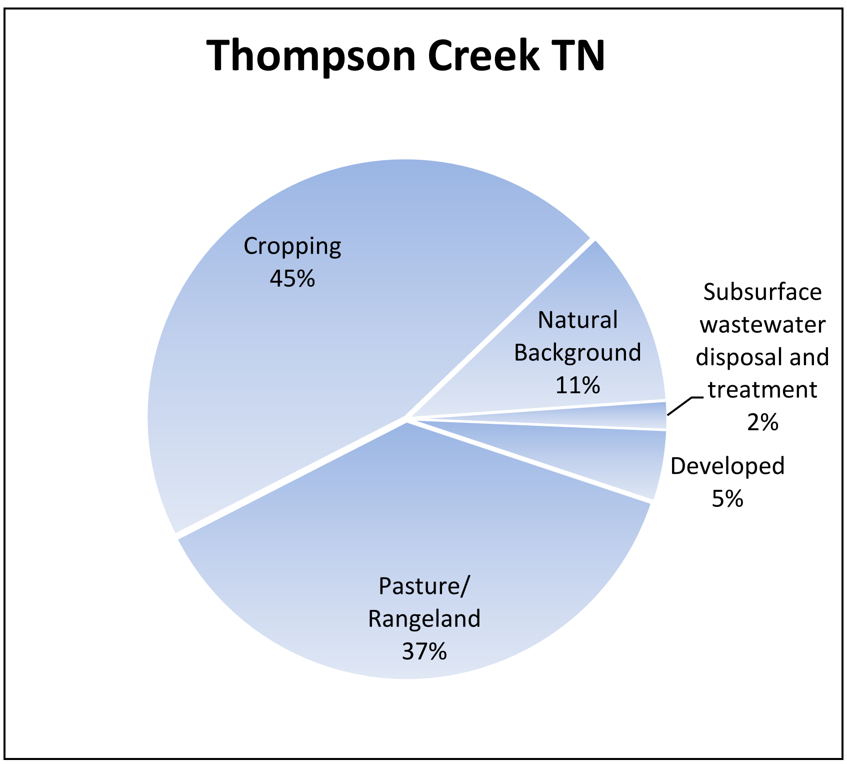

Figure F-34. Existing TN sources for Thompson Creek

F.5 Existing Load Source Assessments for TN and TP for the East Gallatin River

Source assessments for TN and TP on the East Gallatin River presented some unique challenges, foremost among them determining the effect of the City of Bozeman WRF upgrade on downstream water quality. The following source assessments account for the WRF upgrade and reflect existing summer period load conditions in the East Gallatin River. Source assessments performed on tributaries to the East Gallatin River were incorporated into the analysis. Comparison to median reference data vales for TN and TP resulted in outstanding agreement between the two estimates. Therefore, the source assessment natural background calculation was retained for all three segments.

F.5.1 Upper East Gallatin River

The upper segment of the East Gallatin River is listed as impaired for total phosphorus and total nitrogen on the 2012 303(d) list. Figures and analysis for TP and TN source allocations are provided in this section.

In the upper segment of the East Gallatin River, there were few synoptic sampling events where multiple samples were collected along the assessment unit. Upstream tributary data from Bear, Rocky and Jackson Creeks were used to determine the source allocations in upper reaches of the segment (**Section 6**; **Figure 6-1**). As most of the nutrient loading originates in the Bozeman Creek drainage which flows in to the East Gallatin River immediately upstream of EG03, sample data and existing load allocations from this watershed were used for the upper segment of the East Gallatin River as well. The upper segment does not include Bridger Creek which is the start of the middle segment of the East Gallatin River.

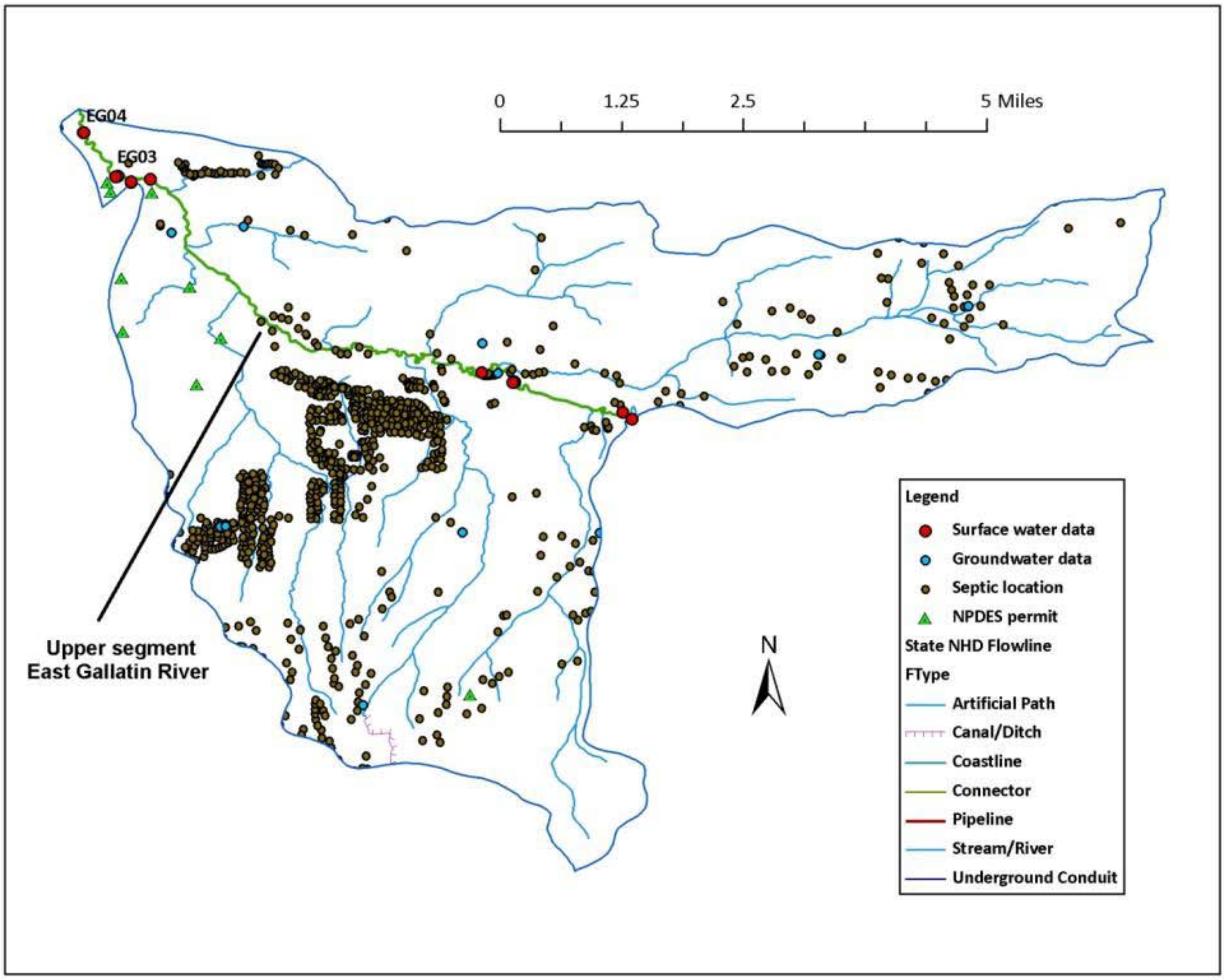

Figure F-35. Spatial data used for the Upper East Gallatin existing load source assessment

Table F-48. Total Nitrogen loading on 9/2/2008 on the East Gallatin River from Rocky and Bear Creeks to Bridger Creek

Site ID	TN load (lbs/day)	Change in load from upstream	% of peak load
EG03	113.74	113.74	100%
EG04	96.50	-17.24	NA

Table F-49. Existing load source assessment for Total Nitrogen on 9/2/2008 on the East Gallatin River from Rocky and Bear Creeks to Bridger Creek

Source category	EG03	EG04	Total
Subsurface wastewater disposal and treatment	13.80		13.80
Forest	3.00		3.00
Developed	20.70		20.70
Pasture/Rangeland	16.56		16.56
Crops	11.04		11.04
Urban	4.14		4.14
Natural Background	31.00		31.00
% of peak load	100.00		

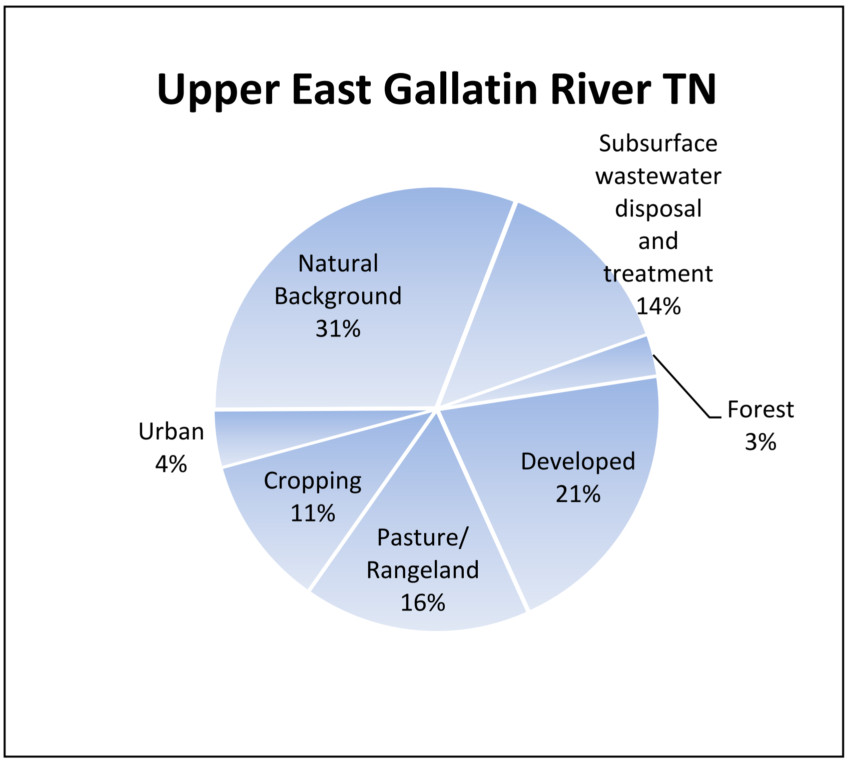

Figure F-36. Existing TN sources for Upper East Gallatin River

Table F-50. Total Phosphorus loading on 9/2/2008 on the East Gallatin River from Rocky and Bear Creeks to Bridger Creek			
Site ID	**TP load (lbs/day)**	**Change in load from upstream**	**% of peak load**
EG03	10.24	10.24	96.5%
EG04	10.61	0.39	3.5%

Table F-51. Existing load source assessment for Total Phosphorus on 9/2/2008 on the East Gallatin River from Rocky and Bear Creeks to Bridger Creek			
Source category	**EG13**	**EG01**	**Total**
Subsurface wastewater disposal and treatment	9.65	0.70	10.35
Forest	13.03	0.00	13.03
Developed	26.06	0.70	26.76
Pasture/Rangeland	11.58	0.18	11.76
Crops	7.72	0.18	7.90
Urban	7.72	1.75	9.47
Natural Background	20.75	0.00	20.75
% of peak load	96.5	3.5	

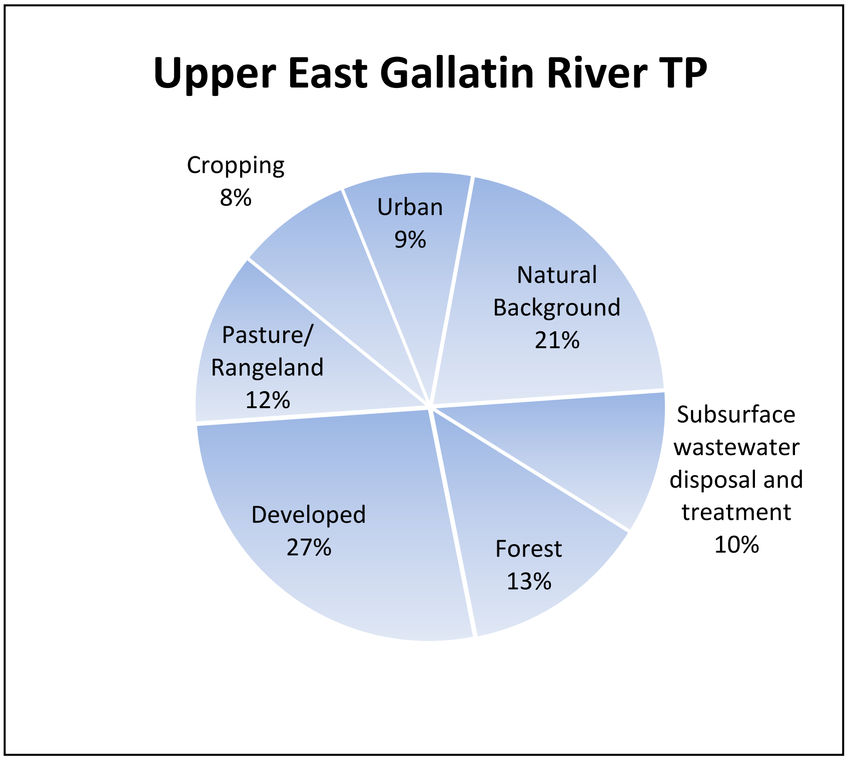

Figure F-37. Existing TP sources for Upper East Gallatin River

F.5.2 Middle East Gallatin River

The middle segment of the East Gallatin River is listed as impaired for total phosphorus and total nitrogen on the 2012 303(d) list. Figures and analysis for TP and TN source allocations are provided in this section.

In the middle segment of the East Gallatin River, tributary data from both TMDL streams and unlisted waterbodies was used to evaluate and determine existing load source allocations. There was extensive data available for this segment which was used in addition to the synoptic sampling. Use of tributary source assessments allowed for incorporation of natural background in the source assessment. This segment includes the discharge from the city of Bozeman Water Reclamation Facility (WRF) and the subsurface wastewater treatment and disposal load from the Belgrade area via Ben Hart Creek.

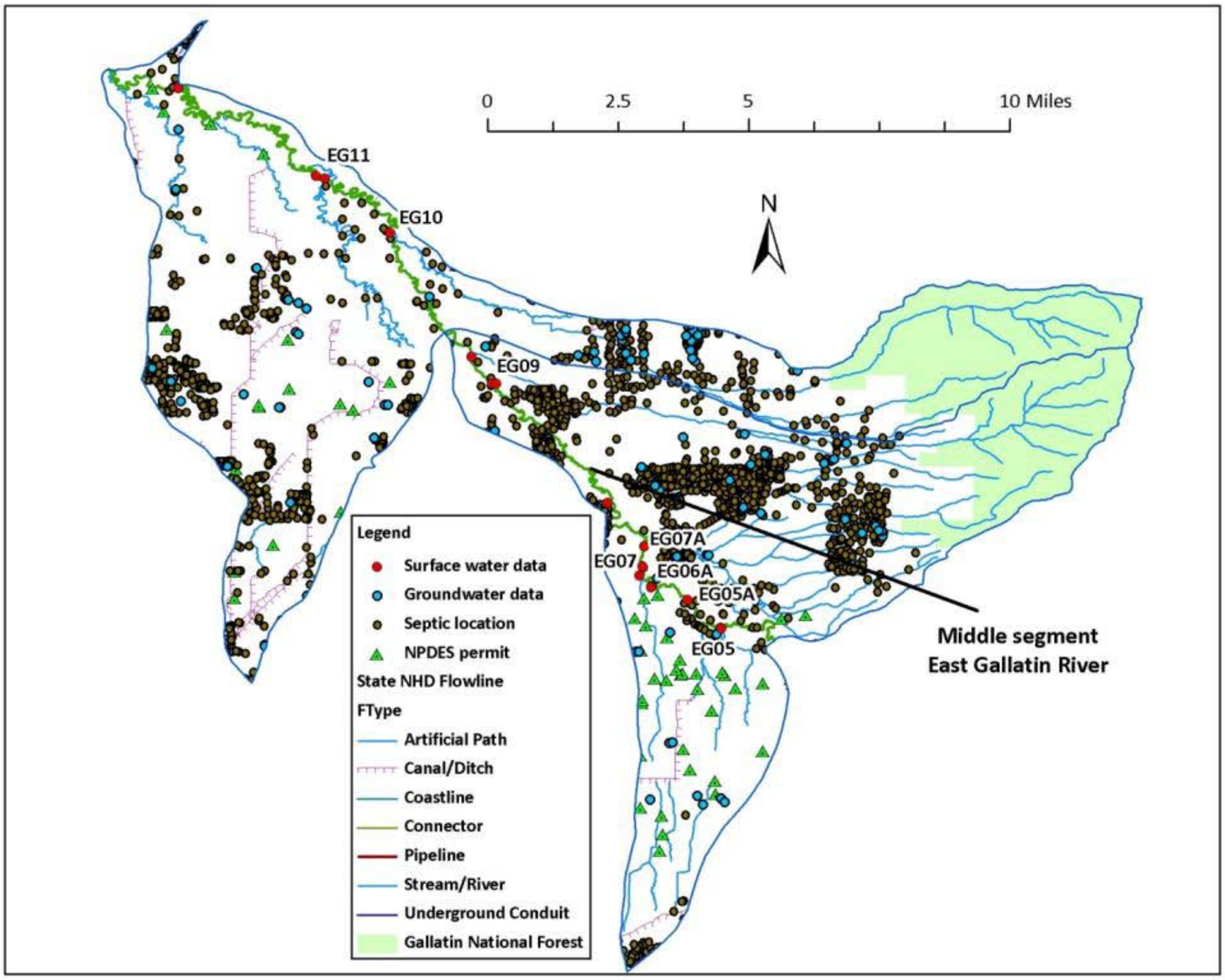

Figure F-38. Spatial data used for the Middle East Gallatin existing load source assessment

Table F-52. Total Nitrogen loading on 9/16/2009 on the East Gallatin River from Bridger Creek to Smith Creek confluence

Site ID	TN load (lbs/day)	Change in load from upstream	% of peak load
EG05	87.50	80.78	15%
EG05A	129.22	41.72	8%
EG06A	99.04	-30.18	NA
EG07	274.32	175.28	32%
EG07A	269.40	-4.91	NA
EG09	106.67	-162.74	NA
EG10	341.00	234.33	42%
EG11	363.28	22.28	4%

Table F-53. Existing load source assessment for Total Nitrogen on 9/16/2009 on the East Gallatin River from Bridger Creek to Smith Creek confluence									
Source category	**EG05**	**EG05A**	**EG06A**	**EG07**	**EG07A**	**EG09**	**EG10**	**EG11**	**Total**
Subsurface wastewater disposal and treatment	2.48	0.26		0.29			7.21	0.07	10.31
Forest	0.73	0.00		0.00			2.54	0.00	3.26
Developed	3.79	2.07		4.77			1.82	0.14	12.59
Pasture/Rangeland	3.21	1.20		1.90			6.13	1.20	13.64
Crops	0.00	3.24		0.00			6.13	1.46	10.82
Urban	0.58	0.75		0.00			0.00	0.00	1.34
Fish Tech Center	0.29	0.00		0.00			0.00	0.00	0.29
City of Bozeman WRF	0.00	0.00		24.66			16.06	1.14	41.86
Natural Background	3.50	0.00		0.00			2.37	0.00	5.86
% of peak load	14.57	7.53		31.62			42.25	4.02	

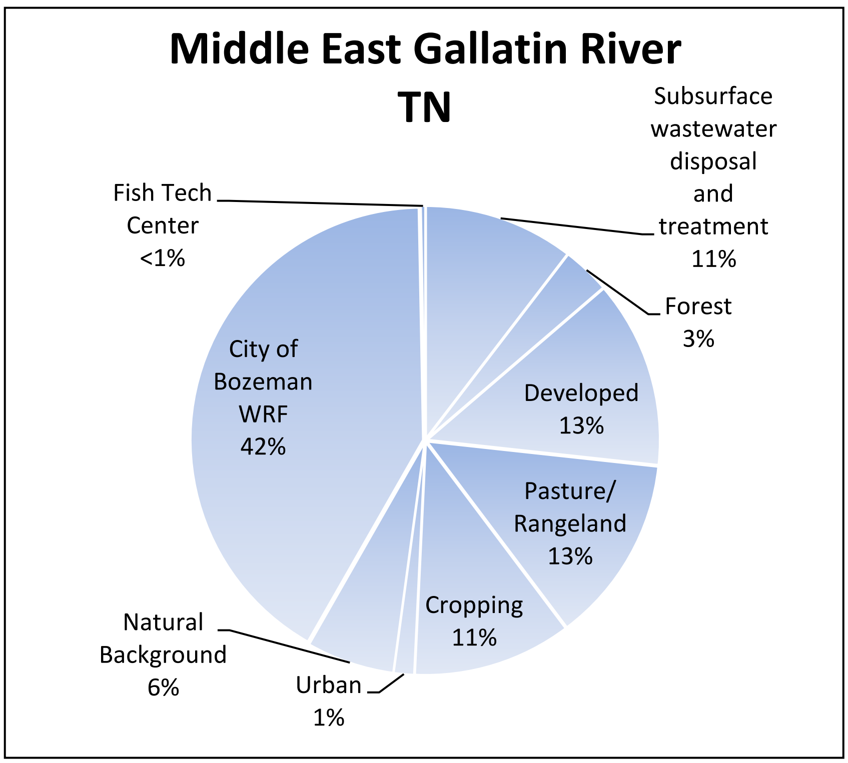

Figure F-39. Existing TN sources for the Middle East Gallatin River

Table F-54. Total Phosphorus loading on 9/16/2009 on the East Gallatin River from Bridger Creek to Smith Creek confluence			
Site ID	**TP load (lbs/day)**	**Change in load from upstream**	**% of peak load**
EG05	4.47	4.242334	9%
EG05A	5.92	1.45	3%
EG06A	5.48	-0.44	NA
EG07	31.68	26.20	55%
EG07A	32.06	0.38	1%
EG09	13.10	-18.95	NA
EG10	28.40	15.29	0.32
EG11	23.93	-4.47	NA

Table F-55. Existing load source assessment for Total Phosphorus on 9/16/2009 on the East Gallatin River from Bridger Creek to Smith Creek confluence									
Source category	**EG05**	**EG05A**	**EG06A**	**EG07**	**EG07A**	**EG09**	**EG10**	**EG11**	**Total**
Subsurface wastewater disposal and treatment	0.89	0.03		2.05	0.03		0.64		3.65
Forest	1.16	0.00		0.00	0.00		0.00		1.16
Developed	2.40	0.91		1.52	0.02		0.64		5.49
Pasture/Rangeland	1.07	0.61		0.00	0.00		0.96		2.64
Crops	0.71	0.91		0.00	0.00		0.00		1.62
Urban	0.80	0.58		0.00	0.00		0.00		1.38
Fish Tech Center	0.00	0.00		0.00	0.00		0.00		0.00
City of Bozeman WRF	0.00	0.00		51.37	0.74		18.60		70.71
Natural Background	1.87	0.00		0.00	0.00		11.22		13.09
% of peak load	8.90	3.04		54.94	0.79		32.07		

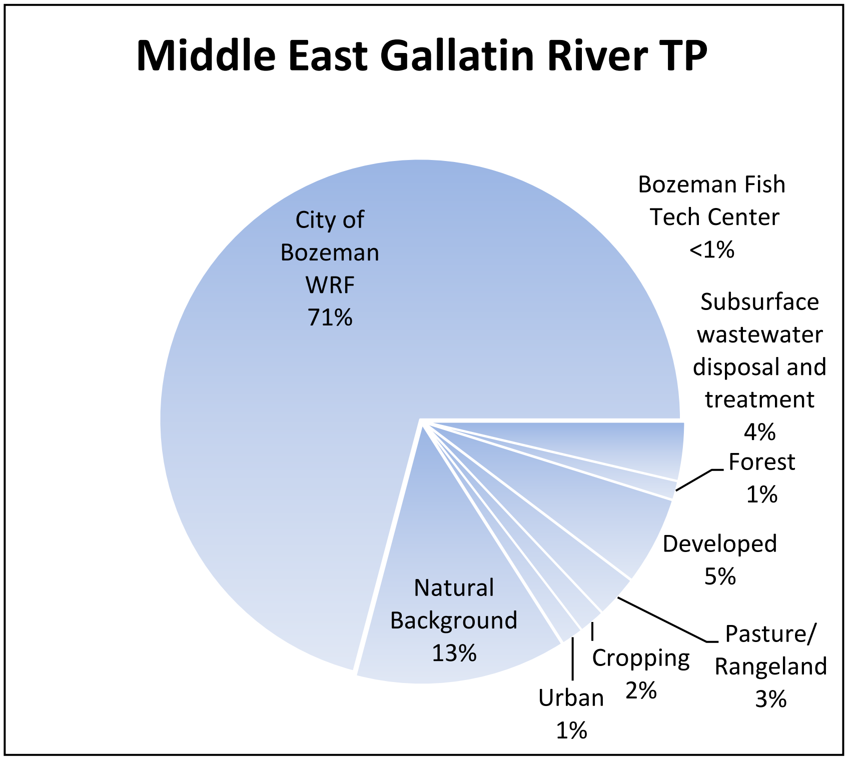

Figure F-40. Existing TP sources for the Middle East Gallatin River

F.5.3 Lower East Gallatin River

The lower segment of the East Gallatin River is listed as impaired for total phosphorus and total nitrogen on the 2012 303(d) list. Figures and analysis for TP and TN source allocations are provided in this section.

Although there was a good dataset available for this segment, there were few synoptic sampling events. However, the September 2009 sampling event did sample many of the smaller tributaries to the lower segment including Ben Hart Creek, Cowan Creek, Gibson Creek, Stony Creek, Thompson Creek, and Ben Hart Creek as were as a few sites on the mainstem. Assessment work was also done on Dry Creek and Smith Creek which flow into the East Gallatin River in this segment. These resources were used to determine the existing load source allocation for the lower segment. The Manhattan WWTP discharge drains to the Gallatin River and was not included in the Lower East Gallatin River existing load assessment.

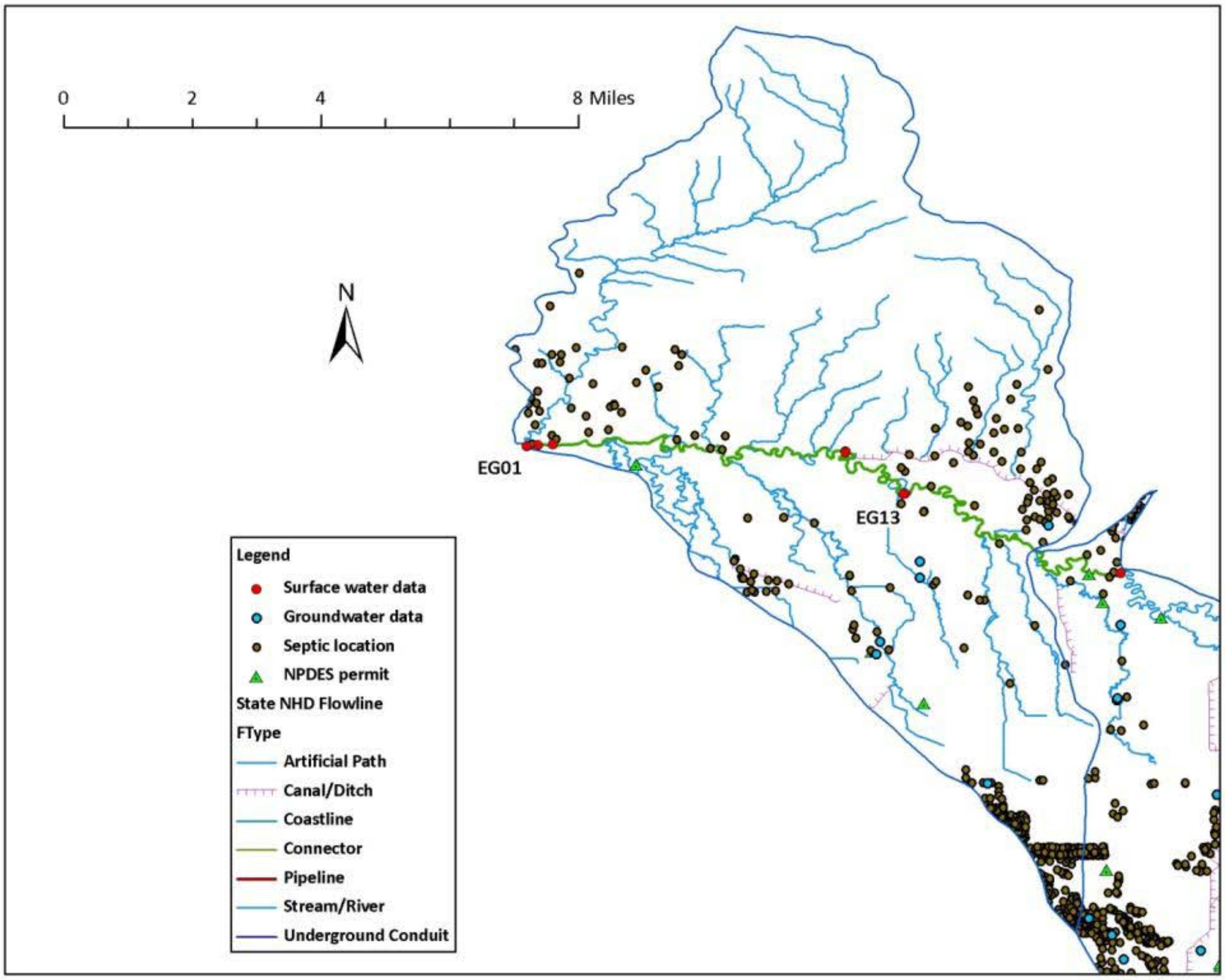

Figure F-41. Spatial data used for the Lower East Gallatin existing load source assessment

Table F-56. Total Nitrogen loading on 9/16/2009 on the East Gallatin River from Smith Creek to the Gallatin River			
Site ID	**TN load (lbs/day)**	**Change in load from upstream**	**% of peak load**
EG13	704.11	340.82	86%
EG01	821.45	117.34	14%

Table F-57. Existing load source assessment for Total Nitrogen on 9/16/2009 on the East Gallatin River from Smith Creek to the Gallatin River			
Source category	**EG13**	**EG01**	**Total**
Subsurface wastewater disposal and treatment	8.43	0.14	8.57
Forest	4.47	0.00	4.47
Developed	7.36	0.14	7.51
Pasture/Rangeland	22.69	5.41	28.10
Crops	26.22	6.85	33.07
Urban	0.43	0.00	0.43
Fish Tech Center	0.00	0.00	0.00
City of Bozeman WRF	14.18	1.71	15.89
Natural Background	1.73	0.00	1.73
% of peak load	85.52	14.27	

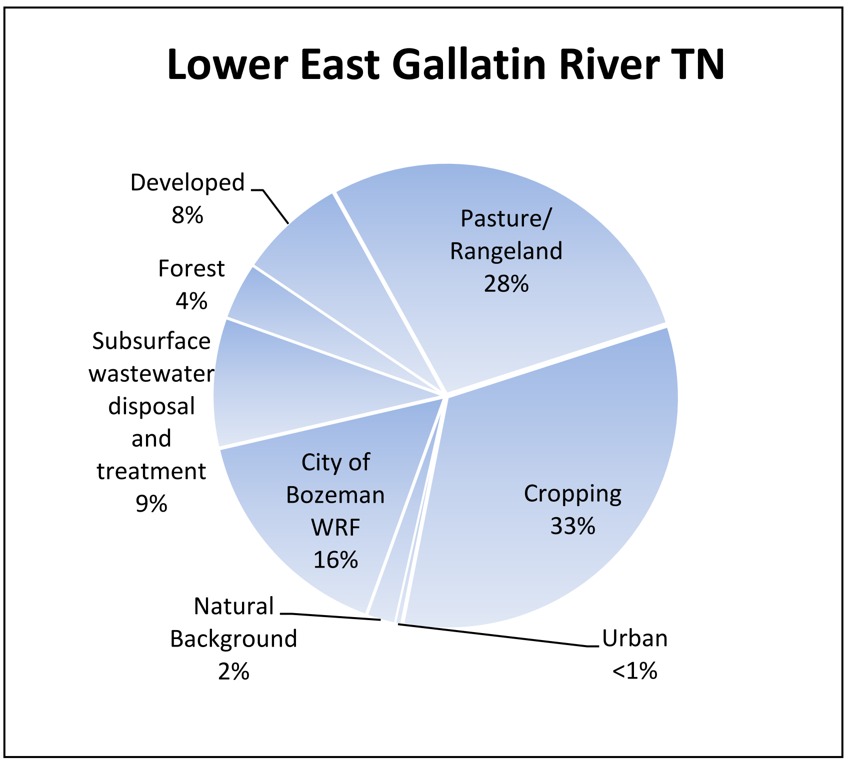

Figure F-42. Existing TN sources for the Lower East Gallatin River

Table F-58. Total Phosphorus loading on 9/16/2009 on the East Gallatin River from Smith Creek to the Gallatin River			
Site ID	**TP load (lbs/day)**	**Change in load from upstream**	**% of peak load**
EG13	25.47	1.53	1.00
EG01	19.16	-6.31	NA

Table F-59. Existing load source assessment for Total Phosphorus on 9/16/2009 on the East Gallatin River from Smith Creek to the Gallatin River			
Source category	**EG13**	**EG01**	**Total**
Subsurface wastewater disposal and treatment	6.48		6.48
Forest	2.10		2.10
Developed	9.89		9.89
Pasture/Rangeland	29.78		29.78
Crops	12.51		12.51
Urban	2.74		2.74
Fish Tech Center	0.00		0.00
City of Bozeman WRF	25.00		25.00
Natural Background	11.50		11.50
% of peak load	100		

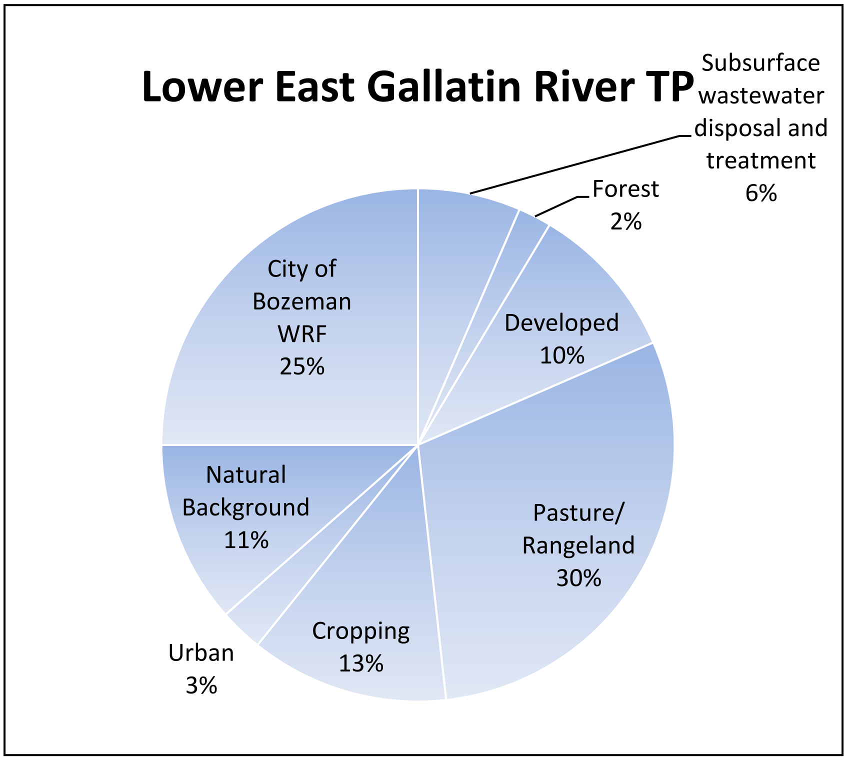

Figure F-43. Existing TP sources for the Lower East Gallatin River